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Synopsis of Science from the standpoint of the nyaya philosophy

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In order that the precise design of this Synopsis of Science may be understood, the compiler has been directed to recapitulate briefly the considerations, detailed in the published Educational reports of the last five years, which have guided his proceedings in regard to the Sanskrit department of the Benares College.

On receiving charge of the Sanskrit College it was my duty to become acquainted with its constitution and history, with a view to introducing whatever improvements might be found consistent with the retention of its character as a seat of Sanskrit learning not unworthy of its classic locality. I was not required to give an opinion whether the funds devoted to the encouragement of Sanskrit learning might be profitably diverted to other purposes. The Sanskrit College was designed to be a permanent institution, and it was not needed that I should deprecate the idea of foregoing in any degree the peculiar advantages offered by such an institution for the advancement of education in India,—advantages for which there could be found no substitute. The proximate end, on which these peculiar advantages seemed capable of being brought effectually to bear, is the development of a language adequate to the reproduction of European thought, and the construction of a scientific literature rightly adapted to our educational purposes, by being in a form congenial to the Hindú mind, and free from barbarisms of speech. It was through the Sanskrit, I perceived clearly, that this must be effected: but it has never been contemplated that in the Sanskrit the results should remain locked up. Such then being the proximate end, it is here to be shown, in chronological order, how the end has been kept in view, and what pro-

gress has been made in sketching a design which would require many hands for its completion.

From a letter of Mr. Jonathan Duncan, the Resident at Benares, dated 24th December 1798, it appears that the Sanskrit College was at that time founded "for the cultivation of the laws, literature, and (as inseparably connected with the two former) religion, of the Hindoos." The discipline of the College, it was added, was "to be conformable in all respects to the *Dharma S'astra* in the chapter on education." These terms, as I remarked in the Report for 1846-47, "appear to contain the germ of nothing beyond the conciliating of the natives of India by paying a graceful compliment to their language and literature, and of perhaps providing better educated Pandits to act as legal counsellors than could otherwise have been always met with. For many years all the efforts of the various gentlemen who took an interest in the College appear to have been directed to the increasing of its efficiency in these respects." The first decided effort which I found recorded for turning the institution to further account was that of Mr. J. Muir, C. S., who undertook the duties of Principal during the session of 1844. Mr. Muir delivered lectures, in Sanskrit, on Moral and Intellectual Philosophy; and the sentiments which he then inculcated have often since that time furnished topics for discussion in the College. On the year 1846-47, my impression, as recorded in the printed report, was this, that in the studies of the Sanskrit College all improvement at present must be in the way of addition, not of substitution, because "The most perfect European education bestowed upon a young Bráhmin, however great a blessing it might be to himself, would exert no beneficial influence beyond his own breast, if unaccompanied by the amount of Sanskrit erudition which is indispensable for securing any degree of respectful attention to his words."

The most interesting experiment of the session 1847-48 was the introduction of the study of English into the Sanskrit College. The repugnance of the pupils to this new study was overcome by the offer, to the Senior Students whose period of study was expired, that they should be allowed to retain their scholarship allowances on condition of their read-

ing English. These men I was very anxious to retain. They had reached a point of mental culture at which they had become worthy of being reasoned with on the comparative merits of the civilization of ancient India and of modern Europe,—a point which the junior pupils were not likely to reach until they in turn should be past the age at which they could retain a scholarship under the existing regulations. Government having sanctioned the proposed experiment, the English class of pandits was formed. Its aspect at the opening of the session, as remarked in the printed report, "was not auspicious. The majority of the pupils were very averse to the study, and seemed to think themselves in some measure degraded in the eyes of the other students. They attended reluctantly, when every device for evading attendance failed:—books were lost or had not been supplied; pens and ink became suddenly unprocurable; and half the time allotted for the lesson was sometimes spent in settling the fastidiously protracted preliminaries. The pandits seemed greatly to dread being desired to attend in the English College Bungalow, where their slender acquirements in English might expose them to a disadvantageous comparison with little boys who had been reading for a year or two. When they found that no such design upon them was really contemplated, their apprehensions gradually wore off, and ultimately they came over (from the building appropriated to the pandits) to the English department, of their own accord, for several hours daily, in order that they might be within reach of assistance when preparing their lessons." The first want of this class was a suitable English grammar, all the existing grammars being, with reference to the pandits, at once redundant and defective, inasmuch as these manuals take for granted that the learner knows nothing of grammar as a science, and that his vernacular is English or a language of similar idiom. I therefore prepared an outline of English grammar in Sanskrit, which was communicated to the pandits in the shape of lectures, and, after having run the gauntlet of their by no means indulgent criticism, was printed for the use of the class.

In the session 1848-49 steps were taken for bringing about some mutual understanding between the students of the Sanskrit and of the Eng-

lish departments respectively. It was noticed, in the report on the year, as a fact to be lamented, "that the advanced scholars of the English and of the Sanskrit Colleges, though speaking the same vernacular, are mutually unintelligible when the conversation turns on the subject of their studies. The technical terms with which they are respectively familiar, being the product of opposite theories, are not convertible by one who is not conversant with both.

"The consequence is, that the Pundits, in full reliance upon a dogmatic, and, as they think, inspired philosophy, which has stood the discussion (such as it has yet encountered) of centuries, look with calm superiority on the pretensions of a more modest philosophy, which avows that it is only progressing towards that perfection which it cannot hope to reach,—whilst on the other hand our English Students, struck by the imposing methodical completeness of the Brahmanic systems, which they cannot comprehend in detail, and bewildered in every attempt to cope with the dialectical subtlety of the Pundits, who, they see perfectly, though unintelligible to the English Student, are quite intelligible to each other, become possessed by an uneasy feeling, that there is more, if they could but come at it, in the Sanskrit philosophy than is dreamt of in ours. Hence comes the apparent anomaly that a man who can expound the Newtonian Astronomy, consults his astrologer with the same deference as the most ignorant villager; and confusedly believes in his heart, what the Jesuit Editors of the "Principia" only professed with their lips, that the earth stands still, though the hypothesis of its motion may suffice to account for the phenomena. Hence it is also, that although acquainted with the theory of eclipses, and able to calculate them by European formulæ, he would not on any account neglect to perform the ceremonies ordained for the purpose of helping the luminary out of the jaws of his mythological enemy, the trunkless demon of the ascending node. The only way to remedy this, is to put such a one in a position to judge for himself by making him sufficiently well-acquainted with both sides of the case. It is scarcely necessary to observe that a decision in our favour carries ten-fold moral force with it when it is known that the person so deciding knows not merely what he embraces, but also, thoroughly, what he deliberately abandons."

With the view of enabling the students of the English department to meet half-way the Sanskrit students who had began the study of Eng-

lish, two steps were taken during the session 1848-1849. The one was the preparation of an English version of the Sanskrit school-grammar, the *Laghu Kaumudi*, with references and comments:—the other was the delivery of a set of lectures on the Nyáya Philosophy. As it may strike the reader, if unacquainted with the subject, that the translating of the *Laghu Kaumudi* was a superfluous labour while English grammars of the Sanskrit already existed, I may be permitted to quote the opinion of Professor H. H. Wilson, to whom the first fasciculus (of about a hundred and fifty pages) had been sent. Professor Wilson says of the version, "It will be of infinite use "to those who wish to learn Sanskrit substantially and in earnest. I "went through the text, as far as your translation extends, with one of "my Oxford pupils, to his great gratification and advantage." The peculiar advantage of studying the Sanskrit grammar in the shape in which it is presented in the *Kaumudi* is this, that the learner is thus prepared to avail himself of the rich treasures of Sanskrit philology, which, to the mere reader of the grammar reduced to the European form, are a sealed book. That the philological works of the Hindús contain much that is yet to be gained from them may be inferred from the anxiety expressed by Dr. Max Müller, the editor of the Vedas, that the "Great Commentary" on PÁṆINI'S Aphorisms should be printed. An edition, sanctioned by Government N. W. P., is in progress here.

The text-book taken for the lectures on the Nyáya Philosophy was the *Tarka-Sangraha*. Here, as remarked in the report, "I took sentence by sentence, first giving the original, which my hearers were able partly to understand; then a translation; and then a commentary, pointing out the correspondence of each part to the several divisions of European science, and noticing anything analogous in the speculations of antiquity that occurred to me as likely to do good, either by showing that the same truths had been hit upon, or the same errors for a time adhered to, *out* of India as well as *in* it. These lectures were listened to with marked interest, the subject being one which the students are ambitious of understanding,—one which can easily be made clear to them with the aid of explanation in English,—and one which the pandits have not the

most distant conception of the possibility of explaining in an exoteric fashion." The Lectures on the *Tarka-sangraha*, including the text and translation, were printed for the use of the College. The discussion which the translation has undergone has suggested various amendments, and an improved translation (accompanied by a version in Hindi) has had the advantage of being superintended, in passing through the press, by my valued coadjutor Mr. F. Edward Hall.

At the annual examination of 1848-49, thinking that some account of the actual nature of an examination of the Sanskrit College might prove interesting, I selected such questions in each department as might give a general idea of the topics which occupy the attention of the native literati. Some of these here follow.

Questions on the Vedanta or Theological system of Philosophy deduced from the Vedas.

"What answer do you give to the objection that if the Divine Spirit be, "as you say, devoid of qualities, it cannot be made the subject of medita- "tion?"

"Determine what is the real state of the case in regard to the following "doubt, viz., whether an elephant and the like, seen in a dream, is or is not "produced at that time, seeing that it has no material cause?"

"How is the opinion of the *Vaiseshika* School of the *Nyaya* sect respect- "ing atoms, to be refuted?"

"Explain the erroneousness of such opinions as that of the soul's being in "the form of an atom?"

Questions on the Sánkhya system of Philosophy (of which the orthodoxy is held to be rather questionable).

"How do you prove that primeval nature has an independent existence?"

"How do you meet the arguments of the Vedantists who deny a duality in "the universe, asserting that nothing exists except God?"

"Prove the existence of the Deity according to the views of the Theistical school?"

"How does the soul, in transmigration, enter another body?"

"By what ascetic practices is a knowledge of the past and the future attainable?"

"How do you know that Quietism is right, and in accordance with Scripture?"

Questions on the Nyáya or Logical and Atomic System of Philosophy.

"What is the distinction recognized by the *Naiyáyikas* between the Supreme Spirit and the living soul?—and what objection is there to the opinion that, of the two, the latter only exists?"

"How do you prove that the mind is in the form of an atom?"

"In the opinion of the *Naiyáyikas*, how many kinds of proof are there, and what are they?"

"How do you prove that gold is identical in substance with light and heat?"

"Before presenting any other questions, it may be well to make some remarks on these. One of the first reflections likely to be suggested by a perusal of these questions is this, that the pupils are taught by one Pundit to establish, of course by irresistible arguments, positions which the Pundit in the next lecture-room teaches him to assail and carry by arguments equally irresistible; and this reflection naturally suggests two questions,—does not this keep the Sanskrit College in a state of feud? and what is the state of the Student's mind after he has gone through the incongruous curriculum? The first question is easily answered. Provided the pupil reads with a given teacher, that teacher seems to have not the slightest objection to his reading with any of the other teachers. With the view of determining in some measure the result of the course of discipline on the minds of the Students, I proposed to the Senior Students the following question.

"'As the three systems of Philosophy which you have studied in the College professedly dispute each other's positions, and cannot therefore all be entirely

" in the right, tell me whether you adopt any one of them to the exclusion of " the others; or, provided you really have formed any opinion of your own at " all, whether you adopt, eclectically, something from each."

" The answers were generally to the effect that all the three systems were reconcilable with Scripture, and that what appeared in any of them to be a deviation from the truth, was in reality only an accomodation to the weakness of the human understanding, which renders it necessary in the first instance to communicate the truth under the garb of error; just as a mother, in pointing out the moon to her child, speaks of it as the shining circle at the end of her finger, which is intelligible to the child, while the mention of its being distant by thousands of leagues would have hopelessly bewildered him. This is plausible; but the habit of viewing the same assertion as true at one moment and false the next, has apparently helped to lead to the existing remarkable indifference as to what is true in itself. Truth, under such circumstances, becomes a matter of taste, concerning which " non est disputandum," except in so far as this disputation may furnish matter of amusement or display. We are not here enquiring into these curious philosophical systems as a mere matter of curiosity. The question of questions in regard to them is here—how, and how far, they are capable of being turned to account.

" Of the three leading Schools, the *Vedánta*, the *Sánkhya*, and the *Nyáya*, the first, being an attempt to reconcile Hindú Scripture with Philosophy, obviously does not promise much to aid us. The second is as nearly as possible a system of Nihilism, though its advocates protest against imputing that character to it. It contains much that is ingenious, and not a little (as Professor Wilson and others have shown) that has been only recently excogitated in Europe. But as a system, it tends to nothing that we can have any interest in promoting. We cannot make its plan therefore the ground-work of any curriculum of our own. The *Nyáya* on the other hand is a very fair, and, in some respects, admirable, attempt, on the part of certain speculative philosophers, who had made perhaps as many observations and experiments as they had opportunities of making, to present a complete and consistent physical as well as metaphysical theory of the universe. Of this system, therefore, I have chiefly made use, in laying the foundations of an attempt to present to the Students of the Sanskrit College an equally comprehensive view of the universe, divested of those errors in their own *Nyáya* which modern observation and experiment have shown to be such, and giving somewhat of its due promi-

nence to the physical departments of science, which were much less prominent in the original exposition of the *Nyâya* doctrine than its metaphysics, to which the physics were entirely subordinated as they have ever since remained. While their system professes to embrace the universe, it really neglects all that forms the subject-matter of the physical sciences, and consequently its professors look down with self-complacent superiority upon the cultivators of physical science, and with indifference upon its results. The case of Astronomy presents only an apparent exception to this rule, for it is for astrological purposes alone that the bulk of the Brahmins value Astronomy. Here, as in other departments, the knowledge that they have, furnishes too often the main obstacle to their acquiring more. But this is only an additional reason why we should take care to ascertain what it is they have; for whatever they possess of truth, will remain an obstacle, until we make it an ally.

"The Hindoo mind for a long period, has been in what Whewell calls the 'commentatorial stage,' a stage in which originality is forbidden and shunned. This would seem to present one of the occasions when a just appreciation of the history of an analogous period may be fairly expected to throw light upon the prospect of the future, on its undesirable probabilities, and its more desirable possibilities, possible only if they be properly anticipated. To this consideration I shall have occasion to revert. In continuation of the purely Sanskrit portion of the examination, I subjoin some of the questions on Grammar, Rhetoric, Law, Mathematics and Astronomy. An inspection of these will show that there is here occasion not so much for the Baconian instruments intended to 'originate motion,' as for those that "direct" it when once originated,—the centripetal force, or wooden yoke, of dogmatic authority, having long since converted, what at the outset was onward progress, into the narrow yet interminable orbit of an ox in an oilmill.

Questions on Grammar.

"What is the province of Grammar?"

"Has a word any sense of its own, or is it merely a mark for the thing signified?"

"According to the opinion of the Grammarians (who are at variance on certain points with the followers of the Nyâya, &c.,) what is the real state of the case in regard to this sentence, viz., Yajnadatta cooks rice?"

"Many other questions were given on this branch, but they related chiefly to the technical treatises on the etymological structure of the language, one of which treatises* I have already mentioned my wish to render accessible to the English reader.

Questions on Rhetorical Composition.

"What are generally the faults that can be committed in the way of composition?"

"What faults can be committed in regard to the management of a simile?"

"What is the difference between a simile and a metaphor?"

"Give some account of the cases in which a metaphor is of such a nature that the thing for which it stands need not be further hinted."

Questions on Law.

"Two full brothers are co-parceners, one of them dies childless, leaving a wife; afterwards the other who has lost his wife also dies, leaving a daughter who is childless, but whose husband is living. State what right to the property belongs respectively to the widow and the daughter, according to the *Mitákshara*, and also according to the *Dáyabhága*."

"A person seated in his carriage drawn by a horse, and driven by an expe driver, is proceeding along the road, and shouting 'keep out of the wa keep out of the way!' As luck will have it, a man is driven over, and k led: which is to pay the penalty, the driver or his master?"

"A she buffalo, with her calf, being entrusted to a keeper during the d time, having eaten another person's corn, lies down to sleep there unhinde ed. In this case what penalty must the owner of the buffalo pay? H much is the owner of the field entitled to receive? Is the keeper blameal or not, and if blameable what penalty must he pay?

"What kind of proof is most effective, and in what kind of cases?"

"Being curious to see what the Students would make of a case for wh they could find no precedent in their law-books, I proposed the case whi Reid cites as an example of an insoluble dilemma,—of the sophist Protago

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* The *Laghu Kaumudí*—since printed.

and his scholar. Just as I expected, they tried it by every one of their technical rules in succession, never doubting, but that one or other of the keys must fit. When they found, to their great surprise, that this was not the case, they betook themselves to the unusual task of unaided thought; and whilst one decided that the judge must decree in favor of the pupil, another said that he must decree in favor of the master, and a third that he had better dismiss the case without giving any opinion on the matter, which last is the resolution that the Greek judges are related to have come to. The law Pundit, to whom these opinions were submitted, took two days to consider the case, which he also tried in vain by his body of rules which never had failed him before. At this he made no secret of his admiration, but at last he hit upon a solution not uncreditable in my opinion to his sagacity, viz., that the pupil was decidedly entitled to a verdict in his favor, and that then this would furnish good ground for a new action in which the teacher must needs gain his point. I mention this as illustrating (what I wish I could illustrate by instances of a character less slight) the lively and salutary excitement which may be created among the Pundits when any thing that they really take an interest in, is presented to them in such a way as to compel them to step out of the beaten track. Unfortunately, in regard to those subjects respecting which their knowledge is most defective, the difficulty is to get them to take any real interest at all. The method which I have found to answer best, is to take as a starting point some established point in their own philosophy, and to show how the philosophers of Europe have followed up the enquiry.

"For example, I found that the Pundits entertained a very low opinion of the European Logic, some account of which had been supplied to them from the popular work of Abercrombie. On this subject I perceived that all my explanations were thrown away, until it occurred to me to enquire carefully whether the knowledge of my hearers did not stop short at some point between which and the knowledge that I wished to communicate, there remained some gap to be filled up, before they could discern that the one was but the continuation of the other. The result was extremely satisfactory. The Pundits, gratified by the admission that their own view of the process of inference is correct so far it goes, laid aside their jealous hostility, which was succeeded by lively curiosity to know how the thing could be carried further;—and thus was obtained, what was wanted, an unprejudiced hearing for what was to be brought forward. It is worth noticing that the very apparatus of technical rules—the "*Barbara Celarent*," &c.,—which now repels so many in Europe,

was hailed at once as an earnest of there being something valuable in the treatise shown to them. The contrivance of significant vowels and indicatory consonants was at once recognized as akin to that of *Pānini* in his institutes of Sanskrit Grammar, and the fact that the system had been matured more than two thousand years ago, invested it with another charm in their eyes.

"These things appear to be worth bearing in mind, for they would seem to indicate that the likeliest way to get the Pundits to lend an unhostile ear to what we have got to say, is to lead them from the very point to which their correct knowledge has attained, as much as possible, by the steps which the European mind itself took in reaching its present conclusions after starting from an analogous point. For example, having secured the attention of a set of Pundits to the Aristotelian Logic, and having thereby gained something of additional respect in their eyes, I explained to them the design and character of the *Novum Organon*, and pointed out which division of their own philosophy,—a division avowedly the least satisfactory of all as hitherto treated by their own authors,—is represented by this great work. I have found no work the general description of which has more excited the curiosity of the most intelligent of my Pundit auditors than this. Of the way in which we are making use of it, I shall have to speak when narrating the studies of the Anglo-Sanskrit class. Bacon himself, though as a classic he will always be read, yet is out of date in Europe as the actual guide in scientific investigation. The employment of his own instrument has enabled subsequent enquirers to detect his own deviations from the right track of discovery: but this very fact, if it be carefully kept in view and properly made use of, gives additional value to his writings as an instrument for promoting the intellectual advancement of India."

During this session, of 1848-49, I delivered to my class of pandits part of a course of lectures, in Sanskrit, on 'The Mutual Relations of the Sciences.'* At the examination the following were—

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* The topics touched upon in these Lectures were—Part 1—Astronomy, Geography, Zoology, Botany, Mineralogy, Geology, Chemistry;—Part 2—Arithmetic, Algebra, Geometry, the Calculus, Mechanics, Hydrostatics, Pneumatics, Acoustics, Heat, Optics;—Part 3—Metaphysics and Mental Philosophy, Formal Logic;—Part 4—The Philosophy of Investigation, Grammar, Rhetoric, Ethics, Law, and History. The four Parts are printed in Sanskrit and English.

Questions on the Lectures of the Session.

"How many planets are there? what is the form of their "orbits? and around what do they revolve?"

"What is the form of the earth? what proportion of its surface is occu-"pied by the ocean?"

"Marine productions are sometimes found in mountain ranges:—account "for this."

"Of what description was the fossil elephant?"

"What is the chemical composition of water, and of atmospheric air?"

The class to whom these questions, in writing, were put and answered in Sanskrit, Mr. D. F. M'Leod, C. S., examined orally on the English books that had been read during the session. Mr. M'Leod remarked as follows:—

"I was present at, and a party to, the examination of this Class in the "'Moral Class book,' Bacon's 'Novum Organon,' and other subjects, inter-"spersed with questions on Grammar, and was very highly gratified by the "result. The acuteness and profundity acquired by these Scholars in the "course of their Sanskrit studies, is carried by them into their English ones, "and brought to bear, with great effect, upon every branch of knowledge in-"troduced to them through that medium. Several of them read with consi-"derable fluency and precision, and though, from the comparative briefness of "the period which has elapsed since they first commenced it, and the great "difficulty of English orthography and pronunciation, much cannot be expec-"ted from them in this respect,—yet, from the answers given, and the mode "of treating the subjects adopted by them, the impression is irresistibly forced "on the examiner that the knowledge they have acquired is in reality greater "than it at first appears: the converse probably, of what might with some "justice be said of most ordinary Classes."

"The Class is, in my opinion, the most interesting and important in the "whole institution. If carried on as it has been commenced, it affords every "promise of realizing the expectation entertained of it by the Principal, with "whom exclusively it has originated; and I most sincerely trust that its aim "and object may never be lost sight of, until the experiment shall have had

"the most complete fulfilment, and its results been exhibited in an unmistake-
"able form."

In the course, above referred to, of lectures to this class of pandits, I followed the division of the sciences adopted by Dr. Arnold in his address to the Rugby Mechanics' Institute.

"But when we arrived at the questions of Metaphysics, the consideration of which I had sought to postpone until we should have gone amicably over some less debatable ground, and thus perhaps have obtained some previously established matter to serve for reference to when illustrations were required, my auditors, accustomed to that strictness of methodical arrangement which is so attractive in their own systems, immediately began to object, (like Demetrius, in the play, to Moonshine with his dog and his thorn-bush—) "Why, all these should be put in the lantern:"—in other words, that what in Europe is treated as a branch of science, under the name of Metaphysics, ought, with some fitter name, to furnish, like their own *Nyáya*, the framework of the whole of the sciences. Having foreseen this objection, I stated to my critics my reasons for having adopted a different order in addressing them, and mentioned my hope that there might be furnished, for the satisfaction of those who felt interested in the preliminary course, a fuller exposition of the sciences, with an arragement modelled on their own.

The Synopsis to which these recapitulatory notices are introductory is an attempt to redeem the pledge thus given. Its principle of construction will be the better understood from the perusal of an extract from the Minute of Mr. M'Leod on the examination of 1848-49. In that Minute, Mr. M'Leod recommends attention to the Report for the year,—

"More especially as, in conjunction with those which have immediately preceded it, it developes the principles and gradual progress (in its application) of what I believe may be considered as an almost entirely novel theory of education, as applied to India, or any other nation similarly circumstanced in respect to its instructors; or at all events one, which in one important respect differs greatly from that which prevails in our other educational Institutions generally.

"Those who have heretofore had the direction of Educational measures in this country—whether on the part of Individuals, Associations, or the Government,

appear to have acted for the most part on the principle of regarding the Hindoo mind, for all practical purposes, as a "tabula rasa" in respect to any pre-conceived ideas, and pre-established system of literature, philosophy, or science either useful and valuable in themselves, or esteemed such by the people with whom we have to deal: and the effects of this appear to me to have been highly prejudicial in many ways; as I think a survey of the general results at our presidencies, as well as elsewhere, will satisfy most candid observers.

"It has tended to segregate from the mass of their countrymen the elêves of our Schools and Colleges; and these, finding that they have no longer ideas in common with those of their brethren who have not been similarly educated, but are rather contemned by a large portion of them, at the same time that they are conscious of being more favorably regarded by the members of the ruling nation, and more nearly assimilating to them in sentiments, have very generally evinced a disposition to regard the former with contempt, and to imitate the least commendable of the peculiarities of the latter; a self-sufficient assumption of superiority taking the place of the humility which a mere entrance within the portals of the vast field of knowledge might be expected to produce. It has also greatly incapacitated these youths for the task of communicating to their countrymen the knowledge which they have themselves acquired, even if other circumstances favored the endeavour; so that except to whatever extent circumstances may in any locality have given extension to the direct study of English, little or no progress has as yet been made towards inoculating the mass with the knowledge of the west; and lastly it has entirely repelled from us, by wounding their self-esteem and pride of learning, those classes who possess, and who unless their position be more stratagetically stormed, I doubt not will yet long continue to possess almost unbounded influence over the large majority of the nation."

Mr. M'Leod goes on to express his hope that, by carrying out the system laid down in the report, the unsatisfactory state of things then existing may be reversed; that "the student of the European school may be brought to understand, appreciate, and sympathize with the Oriental scholar, and the latter with the former;" that "the analogous or identical truths of the systems respectively pursued by each may be traced out and established as common starting points;" and that thus the learned H'ndús "may be conciliated and gradually won over to our cause, and their great erudition and philosophical training brought to bear with effect and

power upon the researches which we most value;" These sentiments of Mr. M'Leod, most accurately embodying the drift of the Report, will suffice to explain the general aim of the following Synopsis. Why the aim has been taken exactly as it has been, it remains to explain.

In the Report for 1849-50, speaking of the English class of pandits, I remarked that—"Aided by these men I shall now listen with simple disregard to the discouraging reiterations of those who insist that the truths of science and of philosophy cannot be communicated to the Hindús without the use of words which would go to barbarize their language; as if a language richer in roots than any European one, and far more finely organized, could not supply as many available terms;—as if the Sanskrit needed instruction at the hands of its grandchild the Greek. To render intelligible our plan of operations for the next session, I may here remark that my first attempt to open a communication with the frequenters of the Sanskrit College was made in the shape of a set of lectures on the circle of the Sciences. The Sanskrit version of these was carefully revised by Pandit Bápú Deva, whose rendering of many of the scientific terms was most felicitous. I learn that these renderings have been incorporated into the English and Sanskrit Dictionary now preparing by Professor Williams for the use of the College at Haileybury. In those portions of the lectures which related to sciences which the pandit had not studied, we were less succesful than in the others. To ensure success it would have been indispensable to investigate the first sources of the nomenclature appropriated to the same or kindred topics in the Hindú Philosophy; and how I propose that this shall be done, I now proceed to state.

"The multitudinous treatises in the six great schools of Hindú Philosophy are all based upon, and are held to be of authority only in so far as they coincide with, the six collections of Aphorisms promulgated severally by the founders of the six schools. The aphorisms were intended not to convey the doctrine but to record it;—hence their oracular brevity. They resemble, in some measure, such formulæ as that of the Binomial Theorem, which, when once explained, enables one to recollect readily a complicated series of facts which—if expressed in words at

length—no human memory could have retained a knowledge of." The Aphorisms, therefore, from the first, had been attended by a comment, oral or written; and, with the aid of these, it was now proposed to make a critical examination of the original Aphorisms, because, "only by tracing the development of Hindú thought, and of the terminology in which it clothed itself, can we hope to avoid completely all such misappropriation of terms as that which has, to a certain extent, baffled all European attempts at translation into the Hindú dialects wherever the subject of discussion transcended the palpable."

It has been already remarked, that, of the Hindú systems, the Nyáya is the one which lends most readily its arrangement and terminology for the conveying of new scientific information intelligibly and satisfactorily to a learned Hindú. Whilst, therefore, the translation of the several systems has been carried on simultaneously,—each system supplying terms and views which will be turned to account,—it was the arrangement of GAUTAMA'S Aphorisms that was adopted as the frame-work of the proposed Synopsis. In his 1st Book (—which, along with the 1st Book of the *Vaiśeshika*, the *Mímánsá*, and the *Vedánta* Aphorisms, has been printed with a translation for the use of the College—) GAUTAMA lays down the plan of the whole Nyáya system. This he effects in sixty Aphorisms. He starts with the grand question of questions—the enquiry as to how we shall attain the *summum bonum*—the "chief end of man." This he declares, in his 1st Aphorism, can be reached only through knowledge of the truth. But have we *instruments* adapted to the acquisition of a knowledge of the truth? We have our senses &c.; and these GAUTAMA enumerates and describes in Aph. 3—8. But, if we have instruments, let us know what are the *objects* to which these are appropriate. GAUTAMA replies to this in Aph. 9—22. But the bare enumeration and definition of objects does not ensure a correct and believing knowledge of them. The state intermediate between hearing and believing—viz. doubt—he defines in Aph. 23. But how is a man to get out of Doubt? He will be content to remain in doubt if there be no *motive* for enquiring further. Here—Aph. 24.—he takes occasion to explain what constitutes a Motive. But in every enquiry, to reach the unknown,

we must start from the *known*;—there must be *data*. These he describes and classifies in Aph. 25—31. The data being determined, it is proper to determine the order of procedure in demonstrating thereby something not granted. This he sets forth in Aph. 32—38. But, thus far, we have been shown an arrangement for hearing only one side of a question, and how can we be sure that the opposite side is not the right one? The propriety of hearing both sides of a question before making up our minds GAUTAMA suggests in Aph. 39-40. But an honest enquirer may have heard both sides and still be in perplexity. Is he to be turned adrift? Not at all. Candid discussion with one who holds the same first principles is open to him;—Aph. 41. There are yet others, besides honest enquirers, that are not utterly to be rejected. A person, not hopelessly irreclaimable, may *wrangle* for the sake of a seeming victory. In Aph. 42, therefore, he defines wrangling. A person, still perhaps not hopelessly irreclaimable, may descend lower than the former by carping at others without undertaking to settle anything himself. In Aph. 43, therefore, he defines cavilling. Wranglers and Cavillers, in default of good reasons, must make use of *fallacies*. The various forms of Fallacy, therefore, he defines in Aph. 44—49. But whilst there are fallacies by which a man may deceive himself as well as others, there are *frauds* which are employed only dishonestly for the deception of others. These he describes in Aph. 50—57. Descending a stage lower, an opponent may employ objections so futile as to be capable of deceiving no one. It is well to know in what consists the futility of such objections. This he shows in Aph. 59. Finally an opponent, sinking even below the former one, (who *knew* what he was opposing, though he could make none but a futile opposition), may be unable to understand the proposition;—Aph. 59-60. Here GAUTAMA'S patience is exhausted, *but not before*. Against everything but the invincible combination of the spirit of contradiction with *stupidity*, he seeks to arm himself at all points. An objection the most frivolous—or even futile—provided it be tendered by one who understands the proposition—he does not refuse to deal with. The objection might perplex some honest enquirer, and therefore GAUTAMA, or the follower who has imbibed his spirit, does not consider himself at liberty to consult his own ease by scouting it,

though he himself may see its futility plainly enough. It is fair to remember this when we meet with ludicrously frivolous objections gravely treated in a Nyáya work. The author is not to be supposed to have *invented* the objection. It was offered to him—offered very possibly for the purpose of vexatiously puzzling and perplexing,—and the Naiyáyika will not allow himself to be puzzled and perplexed. The most cavilling opponent is not to be allowed the semblance of a victory; he shall not be allowed to boast even of having put the philosopher out of temper. This single triumph—such as it is—is reserved for the absolute blockhead.

Now, I should be glad to learn from those who undervalue the *method* of the Nyáya—speaking of its exposition as "tedious, loose, and unmethodical"*—how could that method be much improved? One must not imagine that he has answered this question when he has shown that there are some important matters not here explicitly noticed by GAUTAMA. He must be able to show either that there are important matters for which the system provides no place, or that the order of procedure is misarranged. The order of procedure, according to my own view of it, I have explained. The enquiry whether there is anything within the range of conception, for which the arrangement above sketched does not furnish its appropriate place, is one to which we aim at giving a practical reply in the Synopsis now commenced. Meantime let us take a cursory glance at the range of topics which it will be necessary to deal with in preparing a consistent digest of European knowledge for the use of India.

Knowledge may be subdivided, at the outset, into that which is communicated by Revelation, and that which is searched out by Philosophy. It is with the latter branch that we must at present be concerned. The knowledge that is searched out by Philosophy constitutes Science; and, when applied to the attainment of further ends, it gives rise to Art. Science relates to things that exist as realities, or to their modes of existence. What exists as a reality is either Matter or Spirit. The modes of existence, as Number, Magnitude, and Motion, give rise to such sciences as Arithmetic, Geome-

* Ritter's History of Philosophy—English version—vol. iv. p. 366

try, and Mechanics. Matter may be regarded as Imponderable or Ponderable. Imponderable matter presents itself in the shape of Heat, Electricity, and the like. Ponderable matter may be regarded either as in Atom or in Mass. In Atom, it furnishes the object-matter of Chemistry. Viewing it in Mass, we have the earth either considered in connection with the heavens, by Astronomy ; or considered alone ; superficially, by Geography ; or as to the causes of the existing distribution of its parts, by Geology ; or in regard to its constituent masses. These are either Inorganic, in which case they belong to Mineralogy ; or Organic, the latter division including the Vegetable and the Animal kingdoms. Vegetables are considered structurally in Botany, and functionally in Vegetable Physiology. Animals are considered structurally in Zoology and Anatomy, and functionally under the two physiological conditions of health and disease,—conditions with which the science of Medicine is conversant.

Reverting to the other main branch of the division,—Spirit may be divided into the Supreme Soul, or God, and the Human Soul. Considered as a philosophical question, apart from revelation, the question of the existence and the attributes of God furnishes the topic of Natural Theology. With regard to the human soul, there arise four questions. We may enquire into its nature and operations, as questions of Psychology ; an enquiry with which it is customary to associate the enquiry into Being—or the science of Metaphysics. Secondly, we may enquire into the duties of the soul, or of its possessor. This gives rise to Ethics, private and public. Thirdly, we may make separate enquiry respecting the instruments of the soul—Language, Inference, and Exposition. Language belongs to Grammar ; Inference to Logic ; and Exposition to Rhetoric. Inference again is either of generals from particulars, or of particulars from generals,—so that Logic is either Inductive or Deductive. Fourthly, Soul, or its possessor, may be regarded as the agent in the events of History ; and this may be regarded either as matter of fact, or as something calling for an exertion of the critical faculty. Viewed under the former aspect, it may be subdivided into Political, Religious, and Philosophical. Considering it critically, we have two questions to

ask,—firstly, what are its credentials ; and lastly, what are its lessons.

Assuming that this enumeration includes the topics of a complete liberal education, I am desirous that the whole digest, of which the Synopsis seeks to indicate the starting-points, shall be prepared, in the first instance, with reference, as close as may be, to one of the systems of the universe already current among, and accepted by, the Hindús. In explanation of this, I would beg the readers attention to the two facts, that a mind can be taught only by means of the knowledge that is already in it ; and that a piece of knowledge in any mind —more especially in a mind unfavourably prepossessed—is an obstacle to the reception of any system which, by neglecting to recognize, appears to deny, the truth of that piece of knowledge.* Whatever in the Hindú systems is a portion of the adamantine truth itself, will only serve to baffle our efforts, if, in ignorant impatience, we attempt to sweep it away along with the rubbish that has encrusted it. What kind of engineer should we think him who, when seeking to raise a beacon on the Goodwin sands, should hesitate to acknowledge as a god-send any portion of solid rock, amid the shifting shoals, to which he might rivet one of the stays of his edifice ? When a headstrong opponent of an imperfect system treats with indiscriminate scorn what is true in it and what is false, he has no right to complain that his arguments against the false are as lightly esteemed as his scorn of the true. When the Hindús have only halted at a stage short of that which we ourselves have reached, we should rejoice in being able to present to them our superior knowledge as the legitimate development of what is true in their views, and not in the shape of a contradiction to anything that is erroneous.

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* The scheme of treating the Hindú mind as a tabula rasa, ignoring the existence of Hindú opinions right or wrong, and of attempting to educate India solely by means of the English language, I of course regard as unfeasible. The hopelessness of this somewhat indolent and much too supercilious scheme has been shown by Mr. B. H. Hodgson, in his letters on Indian education, with a clearness that might convince prejudice itself. Let there be as much English education given as possible,—the more the better ;—but let not the delusion be cherished that we shall then have done our part.

It is with such aims that I have made use of the Nyáya system as the framework of the following Synopsis. Wherever in the 1st Book, I have been constrained to dissent from GAUTAMA, I have recorded the amount of divergence in a note. The English reader will perhaps be surprised to find in how few instances I have considered it necessary to record dissent. He may probably think that I ought to have done it in more; but, in regard to this, I trust I shall be able to satisfy the attentive reader as the work proceeds. The style of the commentary will strike the English reader as stiff and ungainly. If he will compare it with the translation of GAUTAMA'S Aphorisms which is interspersed with native comment, he will see that I have intentionally imitated the established style of exposition. My object was, not to introduce a new style, but to convey truth in the style which, as being the established style, was the least likely to provoke cavil.

After completing the first Book, containing the plan of the whole system, I did not consider myself bound to follow the order of GAUTAMA in the development of the matters therein propounded. Having come to an agreement with my Hindú readers as to how much of the first Book we jointly accepted, the development of the accepted portions might of course, without detriment to the mutual understanding between the parties, be carried out in such order of succession as circumstances should render advisable. Now it happens that the Nyáya Philosophy, though furnishing a framework for an encyclopedic body of doctrine, has, in practice, confined itself very much to the topics of Logic and Metaphysics, to the neglect of the topics of Physical Science. This defect it appeared desirable to remedy in the first instance; and, accordingly, my 2nd Book, after a concise account of the Five Senses (in regard to which some erroneous opinions of the Hindús are there corrected), proceeds to treat of "Matter, or that—the qualities of which furnish the objects of the Senses." This leads to Astronomy, Geography, &c. These Sciences are here treated very briefly, because, as I intend the Synopsis to be employed by the Nyáya Professor, and to furnish for his pupils a comprehensive view of the relations of all the principal sciences to the philosophical system of the Nyáya, the main design would be obscured if each topic were treated much more fully. For the use of the other classes respectively

I intend that each of the sections in the Synopsis on Geography, Chemistry, Mechanics, &c., shall form the starting-points of more expanded treatises. The completion of these would require such resources as those of the College of Translators which Mr. B. H. Hodgson has designed, and which I shall not despair of seeing established. In urging the advisableness of preparing a carefully systematized body of instruction, it is of course implied that the irregular and immethodical plan hitherto followed for supplying the desideratum does not appear to me calculated to produce effects correspondent to the labour thus immethodically expended. The plan hitherto has been to say, "Here is a good book—let us translate it." And so a considerable number of books has been translated, and still the want is far from being supplied,—just because no moderate, much less any undigested, selection of books can give the quintessence of the Library of Europe. One book intrudes largely into the province of another; and when this is not attended to, we go on reproducing the same thing over and over again, sometimes in a better shape and sometimes in a worse; and the consequence is, that, while our toil is multiplied, our readers do not add to their knowledge in proportion as they proceed with their reading. The evil of such a state of things in Europe is attempted to be remedied from time to time by the issue of Encyclopedias, which undertake to sum up the total of real knowledge up to the date of publication. The adoption of such a comprehensive method at the outset would have saved, in Indian education, a world of time and expense. It is not too late to adopt it in regard to the Sanskrit, in which hitherto next to nothing has been done to make those conversant with that language acquainted with European Science.

To a reader who is not aware of the relation—the still *existing* relation of the Hindú languages to their living and fostering parent the Sanskrit—the only parent to which they can look up for wholesome nourishment*,—

* In regard to this point I may transcribe the following observations from an article on 'The Prospects of India, Religious and Intellectual' (Benares Magazine, March 1849,) various portions of which, as conveying opinions

it may seem paradoxical when I assert that the fit preparation of a version of any scientific treatise in Hindí, Bengalí, Mahratta, Guzerátí, Támil, Telugú, and Sanskrit, is easier than the preparation of the same set of versions without the Sanskrit one. A little reflection will show that there is nothing strange in this. What is the difficulty—the transcendent difficulty—in translating a European work into an Oriental language? It is the difficulty of determining the exact amount of correspondency between the different portions of the knowledge, on any subject, elaborated by the East and West, and embodied in their respective forms of speech. Different philosophic or scientific theories give rise to different forms of expression; and, where this is disregarded or forgotten, we have the story of Babel repeated indefinitely. Now, this immense difference of cast, both in thought and expression, meets us in every Indian language which we try to make the vehicle of our knowledge; but if the work which it is wished to communicate to all India is once put fitly into Sanskrit, the task is well-nigh done. There is little more difficulty in turning the Sanskrit work into each and all of the

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which I have seen no reason to change, have been incorporated in the present Advertisement.

"It is a great and mischievous mistake to regard the Sanskrit in India as a dead language, in the sense which that term generally suggests. What is meant by a dead language? Nine men out of ten will reply at once that it is a language no longer spoken by the people as their mother-tongue. This definition at once suggests to six men at least out of ten, the idea of a language, the cultivation of which, if desirable at all, is so mainly as a matter of intelligent curiosity. But a very little reflection will suffice to convince any one that of the languages which, in terms of the foregoing definition, may be called "dead," by no means the whole fall under the description here suggested. For example, the Anglo-Saxon is no longer spoken by the people of England, and neither is the Latin. To call them both dead languages, however, does not fairly imply that their claims to attention are equal. In respect of their influence upon the spoken language of the day, the Anglo-Saxon, from which, either as a language or a literature, we have long since ceased to gain anything new, may be regarded as the deceased parent of the English; whilst

vernaculars, when there are properly instructed pandits of all nations at hand, than in turning so many ingots of gold into guineas, sovereigns, and half sovereigns, when the mint is at your command. When a book has been first rendered into unexceptionable Sanskrit, the risk of error, under proper supervision, is at an end; whereas, if translations are made into each language directly from the English, the risk of misconception perpetually recurs. A correct Sanskrit version is like the golden or platina rod deposited in the exchequer office, by which all the brass and wooden yard-measures in the country can be verified, or rectified. To obviate misconception, it may be proper to add, that, I wish the Sanskrit version to be regarded as the measure and criterion of the *sense*, not as the rigid exemplar of the *form* to be adhered to in the vernacular versions to which it shall supply the matter and the scientific terminology.

As it is in the Nyáya class that the Synopsis is to be employed, there is one section of it which I contemplate treating more fully, in the first instance, than the other sections,—the section, namely, of Logic, Ratiocinative and Inductive. In the Sanskrit Lectures on the Mutual Relations of the Sciences, I furnished the Nyáya pandit with a concise ex-

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the Latin, from which our language receives yearly accretions, and by whose literature the minds of each successive generation are moulded, acts the part of a living nurse—though we may choose to hold it technically dead. But if the difference be great between these two, which is hidden under the general name of "dead language," much more momentous is the difference which can slip fallaciously out of sight when the same conveniently loose cloak of a generalization based on the non-essential throws its misty folds around the Sanskrit also. The Sanskrit, to all intents and purposes of any consequence, is no more dead than our reader, who would be able to insure his life on his own terms, if he could show that he had the slightest chance of surviving it.

In the Dedication prefixed to the first Edition of his Dictionary, but omitted in the second, Professor H. H. Wilson remarks:—

"The value of the *Sanskrit* language, as an object of literary curiosity, is of no moment, compared with its importance in the light in which it must be

position of the European theory of the Syllogism ; and his pupils, while studying it, were not a little struck with the technical apparatus of. "Barbara, Celarent, &c.," resembling so closely as it does, in its employment of indicatory vowels and consonants, the time-honoured technical apparatus of the Sanskrit Grammar. In a sketch of "The Philosophy of Investigation," I adopted, from Sir John Herschel's Discourse, the fine example of Induction furnished by Dr. Wells's theory of the formation of Dew. In constructing both of these tracts in Sanskrit, I found it very difficult to satisfy the pandits. The fact being that they had a system of their own, unless all the terms were employed in strict accordance with that system, continual misconception was inevitable. Our modern conception of Induction being that to which is particularly to be attributed our superior progress in science, it appeared highly important, since there existed such a difficulty in coming to a mutual understanding, that the Hindú speculations on the subject should be carefully investigated ; and I was therefore glad at this time to receive from Professor H. H. Wilson a letter suggesting that a translation of the *Anumána Khaṇḍa*, or "Section on Inference," the standard treatise on Hindú Logic, would be very acceptable to the logicians of Europe. An examination of the work in question showed me a greater resemblance than I could have hoped to find between the turn of thought and expression in the writer and in Mr. John Stuart Mill, whose work, on "Logic, Ratiocinative and Inductive," I had begun to employ, with good prospect of advantage, in reading with my class of pandits. Two treatises have therefore been commenced, and put to press ;—the one to consist of such a commented abstract of Mr. Mill's work as may best suit at present the class of readers for whom it is intended,—and the other, of a translation of the parallel Sanskrit treatise abovementioned, on the

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viewed by all who duly consider its connexion with the welfare of this country."

This is an important testimony from a scholar, whose tastes and acquirements would tend to anything rather than to make him underrate the value of a thing "as an object of literary curiosity compared with its value in any other point of view."

same subject, to be studied in the English department also of the College.

For the use of the students in the English department, I prepared, as a sequel to the Lectures on the Nyáya Philosophy, a Lecture on the Sánkhya Philosophy, embracing the text, with translation, of the *Tattwa-samása;* and a Lecture on the Vedánta Philosophy, embracing the text, with translation, of the *Vedánta-sára.** These works, having been since printed, are available as portions of a course of Sanskrit study which, it is hoped, may be gradually introduced in the English department as a discipline analogous, in its benefits, to the study of the classics in Europe. A fasciculus of the excellent text-book of the Nyáya employed in Bengal has also been printed, with a translation, for the use of the English pupils; and, to smooth the entrance to the grammar, I have prepared, with the aid of Mr. Hall, a series of "First Lessons in Sanskrit" on the method of Ollendorff, each sheet as it was printed being supplied to the classes. By such means we aim at rendering Sanskrit, with all its fine capabilities as a disciplinal study, no longer a thing here attainable only at the expense of a life-time; and it is thus that we aim further at making the English and the Sanskrit departments of the College understand each other on subjects in regard to which hitherto the students of the two departments, though speaking the same Vernacular, could as little understand each other as the inhabitants of separate planets with separate natural laws. The reader unacquainted with the facts

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* In the preface to this translation it is remarked as follows:—"That this exposition of the most abstruse of the Hindú systems should be faultless, is very far from probable. In bringing it—as it now stands—before the senior English students, and the class of pandits, in the Benares College, who have for some time been studying English, the intention includes its being submitted to a searching criticism, so that any errors entertained in regard to the system, by Europeans, may have the better chance of being discovered and rectified." The same remark applies to all my other translations. Though no pains has been spared on them, and they are the result of labour curiously disproportioned to the smallness of their bulk, yet I do not presume to offer them to the scholars of Europe except as *proof-sheets* awaiting correction.

may find it difficult to conceive this :—I give him my word for it. Another standard work, the treatise on literary criticism entitled the *Sáhitya Darpana*, has been selected as a portion of the course of Sanskrit study designed for the English department. The printing of this work, with its translation, as the subject seemed likely to interest European scholars, has been undertaken by the Asiatic Society; and the first fasciculus is now published as a portion of the 'Bibliotheca Indica.' I trust that in due time the whole of the course of study pursued in the Sanskrit department will become by such means opened to the pupils of the English department; and I am not without hopes that when this shall be the case, a collateral result will be the removal (from the minds of those competent to judge) of a considerable amount of misconception at present existing in regard to the nature and value of a Sanskrit education. The Oxonian who rightly esteems Aristotle will not disesteem Gautama and Siromani when he becomes equally well acquainted with them.

In the Benares College,—besides the Arabic and Persian department, which does not come within the scope of the present notice,—there is another department not yet adverted to, viz., the Hindí. According to the native system the young Bráhman is confined to the study of the Sanskrit grammar for a protracted period before he learns anything besides the sounds and inflections of words. This arrangement being objectionable, the younger students of Sanskrit are now formed, during certain hours of the day, into classes for the study of various matters of useful knowledge, such as Geography, Arithmetic, Mensuration, &c., in their vernacular Hindí. The various Sanskrit works rendered into English for the other department are to be rendered also into Hindí for the use of these students; and some progress has been made in this direction.

Such,—as regards the enlisting of the Sanskrit on the side of progress,—is an outline of what has been attempted, during the last five years, in the Benares College. It was scarcely to be wondered at that a line of operations such as I have sketched,—designed to make the learning of the Hindús a strong ally instead of a stubborn opponent,—should occasionally be mistaken for a fond admiration of Sanskrit scholarship

and an injudicious undervaluing of everything else in comparison. To show that this is quite a misconception, enough has been now said.

Benares College,
31st July, 1851. } J. R. B.

THE FOLLOWING IS A TRANSLATION OF THE SANSKRIT PREFACE.

That intelligent persons should differ in opinion on any matter of importance is cause of regret. It is another cause of regret that intelligent persons should imagine that they differ in opinion where they really do not differ. How much of useless altercation or of unjust censure is likely to result from such mutual misapprehension, it would be superfluous to insist upon. It can never be an unworthy aim to endeavour to remove any mutual misapprehension which tends to make even two individuals think unworthily of one another: how much less so, then, where the mutual misapprehension exists between two great sections of the earth's inhabitants. The attempt is one in, which even to have failed may be no disgrace.

The Hindús have an ancient literature which they cherish with affectionate pride. In this they do well. Europeans have a literature for which the praise is claimed that it is daily adding to the intellectual wealth of mankind. If Europeans regard their literature, in this aspect, with an affectionate pride, they also do well. But if the European, not rightly perceiving how the Hindú is asserting some unquestionable truth, in phraseology to which the European is unaccustomed, shall condemn the Hindú as asserting an error, he unknowingly commits injustice; and the Hindú is liable to commit the like injustice in return. This liability to mutual misapprehension being very undesirable, it is desirable that a remedy for it should be devised.

As two opposite opinions cannot both be right, and as there can be no good, and there may be much harm, in holding a wrong opinion, it is reasonable that intelligent men, when they differ in opinion, should amicably discuss their difference. This, however, cannot be satisfactorily done unless they clearly apprehend what their difference amounts to; and, as a difference

commences where agreement ends, it is desirable in every case to determine as accurately as possible how far the agreement extends, in order that we may not be liable, in the heat of argument, to dispute about that which is not a matter of disagreement.

Having resolved, therefore, to attempt to determine the extent of agreement between European and Indian thinkers, it became a question what exposition should be assumed as most fully and fairly representing the sentiments of the Hindús. There was no difficulty in selecting the Nyáya in the first instance, because this system of philosophy, while it adverts, in some way or other, to all the topics considered in the other systems, takes cognizance also of various matters which the other systems disregard. Although other systems of philosophy, besides the Nyáya, are accepted in India, yet it suffices if we determine how far the sentiments of Europeans accord with those of the Nyáya, because, if a reader knows what relation the Nyáya bears to the Sánkhya or the Vedánta, with which he holds the Nyáya to be reconcileable, he must understand the relation of European philosophy to each of the other two if he understands its relation to this one. He who already knows the relative bearings of the three great places of pilgrimage, *Kási*, *Gayá*, and *Prayága*, should be able to estimate the bearing of the second and third of these in respect of any fourth city, if he knows how that city lies in respect of the first.

In the first book of his Aphorisms, *GAUTAMA* lays down the plan of the whole Nyáya system. The reader to whom the present work is addressed is supposed to be conversant with the first book of the Nyáya Aphorisms. Such a reader will at once see how far we agree with GAUTAMA, and in regard to what points we differ from him. It has been thought advisable that, after determining thus much, we should then, instead of discussing the points of difference, rather go on to the development of the points of agreement, in the hope that, in the course of such an enquiry, the points of difference may either disappear or may have such light thrown upon them that we may be the better prepared to deal with them.

It has been the endeavour throughout to make the exposition as simple as possible, but the reader who is unacquainted with European literature must not be surprised if he meets here some things hard to understand. Almost every treatise on any novel topic requires to have light thrown upon it by an oral instructor. The reader, therefore, where he does not clearly see the sense,

will do well to enquire of some one competent to explain and illustrate, rather than lay aside the book with the conviction that it is unmeaning because the meaning is not at once everywhere clear to him. It is in particular difficult to convey, by means of words alone, an adequate conception of such facts as can be best exhibited by experimental illustration.

The reader, if he be, as is not improbable, fond of abstract speculation, such as is found in the logical sections of the Nyáya, ought not to regard with impatience the discussion of facts in regard to the properties of material things, to which we have seen fit to devote the 2nd Book, because, unless we have an ample body of recognised facts, it is impossible properly to exemplify and justify the logical processes of scientific enquiry which will furnish the subject of a future Book. If, on a hasty glance, it should seem to him that the discussion of wheels and hammers and ropes is beneath the dignity of philosophy, we would remind him that his own revered teachers of Astronomy give to the learner his first conceptions of the arrangement of the heavens by means of an armillary sphere formed of little hoops of bamboo, and that the Indian logician has not disdained to study the wheel of the potter, though he has not yet learned from it all that it is qualified to teach.

A

SYNOPSIS OF SCIENCE.

Glory be to God the Most High!

Having long pondered the import of the Aphorisms of Gautama, I compose a treatise, on a new plan, showing to what extent the sentiments of the English coincide with those of Gautama. Through the divine favour, may this work of mine, the result of not a little labour, treating of many matters in few words and yet plainly, prove acceptable to the intelligent.*

It is agreed alike by the learned of India and by the learned of other countries that the Chief End of Man† is not to be attained without a knowledge of the truth in regard to our souls and other things which it is desirable should be rightly known. Those, therefore, who aim at the Chief End of Man are bound to strive after the attainment of right knowledge.

The attainment of knowledge pre-supposes the possession of instruments adapted to its attainment; therefore, proceeding to

* As all Sanskrit books commence with an invocation or a benediction, suggesting in some measure the subject of the work, the example has been followed in the present instance.

† This expression of the Westminster catechism corresponds verbatim with the Sanskrit expression *parama-purush-ártha*.

consider these instruments, we give them the first place in the enumeration, here following, of the topics which we propose to consider in succession.

BOOK I.

SECTION I.

THE END OF THE PROPOSED ENQUIRY.

Aphorism I.

Since a knowledge of the truth is conducive to the attainment of the Chief End of Man, we propose to enquire into the truth respecting (1) our instruments for acquiring knowledge, (2) the objects to which these are applicable, (3) the state antecedent to knowledge, viz., doubt, (4) the motives for passing from the state of doubt to that of knowledge, (5) data to start with, whether popular or (6) scientific, (7) the steps in explicating from data what is implied in them, (8) the method of confuting error, so as to arrive at (9) certainty, (10) the nature of fair debate, (11) of wrangling, (12) of cavilling, (13) of fallacies, (14) of disingenuous artifices, (15) futile oppositions and (16) unfitness to be reasoned with.*

a. A Hindú reader will expect that we should here state formally the replies to four questions,—viz.—What is the object-matter of the work?—What is the motive for reading it?—What

* In our first aphorism we depart from Gautama thus far, that whereas he declares the attainment of the Chief End of Man to result necessarily from a knowledge of the truth, we on the other hand regard knowledge as merely conducing to its attainment. What may be requisite in addition does not here fall to be considered.

is the relation between the object-matter and the work?—and—Who is the reader to whom the work is addressed? To these questions we thus reply:—The object-matter is whatever truth we have got to tell in regard to the topics above enumerated;—the motive for reading it is supplied by the knowledge of truth that may be found in it,—knowledge of truth being presumed conducive to the attainment of the Chief End of Man;—the relation between the object-matter and the work is that of a communication and its communicator;—and the reader to whom the work is addressed is he who, being devoid of malice, wishes to know whatever of truth we have got to tell him.

b. As the knowledge of truth is not directly, but mediately, conducive to the attainment of the Chief End of Man, the next aphorism declares the order of the steps through which it conduces to that end.

Aphorism II.

The Chief End of Man is to be attained not without the removal of such False Notions as lead to those Emotions from which, in our present Life, arise Actions such as lead to misery.*

a. What we mean to say is this, that there do exist erroneous notions of various kinds; and these give rise to improper feelings, such as covetousness or envy; and these lead, in this life, to wicked actions; and these in their turn lead to misery. Now

* In this aphorism whilst retaining, for future reference, or substituting equivalents for, the terms in Gautama's 2d aphorism, we dissent from him in so far as we do not hold that all emotions deserve the name of faults (*dosha*), nor that a man's being born into the world is the consequence of his actions in any previous life, nor that the removal of false notions will necessarily and of itself lead to beatitude. We agree with him only thus far that the removal of false notions is conducive to the end desired, so far forth as their existence places obstacles in the way of its attainment.

true knowledge puts an end to erroneous notions; and, unless these depart, the improper feelings which they produce will not depart;* and, unless these bad feelings be removed, the wicked actions which, in this life, arise from them, will not depart; and unless wicked actions be done away with, the misery which these entail will not cease; and the Chief End of Man is incompatible with the continuance of misery.

b. Now, since a definition will be looked for, of each of the things enunciated in the 1st aphorism, in the order of enunciation, we proceed to define and to divide the instruments in the acquisition of knowledge—these being what were first enounced.

SECTION II.

THE INSTRUMENTS AVAILABLE IN PROSECUTING THE ENQUIRY.

Aphorism III.

Our instruments adapted to the attainment of right knowledge are (1) the deliverances of sense, and (2) the recognitionof signs.

a. The name of a *proof* is also given to what is here termed an instrument adapted to the attainment of right knowledge or knowledge of the truth. We divide what is so termed into

* It will be observed that whilst we hold that evil deeds tend, in the dispensations of Providence, to the evil of the doer, and evil deeds arise from evil inclinations, yet we do not say that all evil inclinations arise from erroneous notions. Whether that be the case or not, we are not now enquiring. We agree with Gautama only thus far—that whatever evils are due to a false notion may be expected to continue until the removal of that false notion in which they take their rise.

two—the same to which are usually given the names of Perception and Inference.

b. But then some one may ask,—Since Testimony and Comparison also are instruments by means of which we acquire right knowledge, how comes it that you say there are only two* such instruments? To this we reply,—that Testimony is not a separately co-ordinate instrument of knowledge, because it is just the instrument of an inference (or, in other words, Testimony, when received in evidence, is "the recognition of a sign") where the sign is an assertion. So again, Comparison (or the ascertaining that an object never previously beheld by us is so and so, because it resembles some well-known object which we had been told that so and so resembled,) is nothing else than inferring—in reliance on testimony. Hence we hold that there are only two co-ordinate divisions of proof.

c. We proceed to define the instruments of knowledge, as thus bi-partitely divided, in their order.

Aphorism IV.

By a deliverance of sense is meant the knowledge which has arisen from the contact of an organ of sense with its object.

a. That is to say,—that instrument of correct knowledge which arises from the contact of an organ of sense with its object is a deliverance of sense, or a sensation—such as that of Sight for example.

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* Gautama holds that we have four instruments for acquiring knowledge. Kapila, the founder of the *Sánkhya* school does not recognise Comparison as co-ordinate with the others; and *Kaṇáda*, the founder of the *Vais'eshika* school, recognises only two members in the first division, giving the reason which we have adopted above.

b. Next we have to define and divide the 'recognition of a sign.'

Aphorism V.

Now the recognition of a sign, which is preceded thereby, is of three kinds, (1) having (as the sign) the *prior*, or (2) having (as the sign) the *posterior*, or else (3) consisting in the *perception of homogeneousness*.

a. In saying 'preceded thereby' we mean 'preceded by a deliverance of sense' (—for else the recognition of the sign were impossible).

b. The inference is said to be *à priori* (or, in other words, the instrument of our knowledge involves something *prior* to what is thereby known,) when an effect is inferred from its cause; as when, from the rising of clouds, it is inferred that there will be rain.

c. The inference is said to be *à posteriori* (or, in other words, the instrument of our knowledge involves something *posterior* to what is thereby known,) when a cause is inferred from its effect; as when, on seeing that the water of a river is changed in colour from what it was before, or that the channel has become full, or that the stream runs more rapidly, we infer that there has been rain.

d. The inference is said to be *from analogy* (or, in other words, 'the perception of homogeneousness' is the instrument of our knowledge,) when, for example, on seeing somewhere a mango-tree in blossom, we infer that the mango-trees in other places also are blossoming.

e. Although we do not hold Comparison and Testimony to be, as proofs, co-ordinate with the foregoing, we shall follow Gautama's order, in now describing them, so that the reader may

know what cases of inference these two are. First, then, Comparison, as defined by Gautama, is as follows.

Aphorism VI.

The 'recognition of likeness' is the instrument in the ascertaining, of that which was to be ascertained, through similarity to something previously well-known.

a. That is to say,—as when a man, having been told that the animal called the Bos Gavaeus is like a cow, recognises the Bos Gavaeus, on first seeing it, from its likeness to a cow, so in other cases where certainty is arrived at through the recognition of the resemblance of anything to something previously well-known, the instrument of knowledge, according to Gautama, is Comparison (*upamána*).

b. Testimony is defined by Gautama as follows.

Aphorism VII.

Testimony (as an instrument of *right* knowledge) is the word of one worthy (to have his words implicitly accepted as an authority).

a. Testimony is divisible as follows.

Aphorism VIII.

It is of two kinds, in respect that it may be 'that whereof the matter is seen', or 'that whereof the matter is unseen.'

a. By the 'it' is meant testimony. By the testimony, or verbal expression, 'whereof the matter is seen' is meant that speech the thing referred to in which is here patent to the senses,—as when the river Ganges is what is spoken of. That speech, the things referred to in which are not here patent to the senses, is

what we mean by 'that whereof the matter is unseen,'—as is the case when Paradise or the like is spoken of.*

b. Here, for the present, we quit the topic of the instruments available for the attainment of correct knowledge.

c. As it will be expected that we should next consider what it is to which these instruments are applicable, we now turn to the topic of the *objects* of cognition.

SECTION III.

THE OBJECTS ABOUT WHICH THE ENQUIRY IS CONCERNED.

d. We divide and define as follows the objects concerning which it is desirable that we should have right notions.

Aphorism IX.

Soul, body, sense, sense-object, understanding, the mind, evil deeds, evil passions, mundane life, retribution, pain, and the Chief End of Man,—such are the objects concerning which it is desirable that we should have right notions.†

a. Among these objects, the one first enounced, viz. Soul, may be thus defined.

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* In other words, assertions are of two kinds—where the thing asserted is open to verification by the senses, and where it is not.

† Here we depart from Gautama in substituting 'evil deeds' for 'activity' (which, as before remarked, we do not allow to be essentially faulty),—'evil passions' for 'faults,' under which head Gautama lumps all the emotions, good or bad,—and 'mundane life' for 'transmigration,' of which more anon.

Aphorism X.

Desire, aversion, volition, pleasure, pain, and knowledge, are the sign of the Soul.

a. The word 'sign' here means a characteristic mark—or that whereby such and such an object is recognised.

b. Next in order we have to define the sense of the term Body.

Aphorism XI.

The body is the site of muscular action, of the organs [of sense], and of the sentiments [of pleasure or pain experienced by the soul].

a. 'Muscular action' (*cheshṭá*) is that species of action which originates in voluntary effort (*prayatna*).

b. The 'organs [of sense]' are the Sight &c.

c. The 'sentiments [here spoken of]' are pleasure and pain.

d. The meaning is this, that the body is the site of all these; and that each of these severally, viz., the being the site of muscular action, &c., is a characteristic of the body.

e. Now we have to divide and define the 'organs,' which next present themselves.

Aphorism XII.

The organs [of sense], viz., the Smell, the Taste, the Sight, the Touch, and the Hearing, are what apprehend the qualities of the Elements and of things formed of these.

a. Which are those 'Elements' shall be considered presently. We mean here, when we say that the organs of sense are what apprehend the qualities of these external things, that

each organ is distinguished by its apprehension of its own particular object [—the Sight apprehending colour, the Hearing having sound for its object, &c.].

b. As we shall be asked what we mean by 'the 'Elements' we reply :—

Aphorism XIII.

The Elements are Gold &c.*

a. Whether 'earth &c.,' are entitled to the name of 'Elements (*bhúta*) we shall consider in the sequel.

b. We have now to divide and define 'Sense-object,' which presents itself next in order.

Aphorism XIV.

Their objects are the qualities of the Elements and of things formed of these,—meaning the qualities odour, savour, colour, tangibility, and sound.

a. By the 'Elements' we mean Gold &c., meaning by the '&c,' various things that will be spoken of in the sequel. The qualities, here referred to, of these various objects, are odours &c.,—these being the objects of the senses.

b. We proceed to define 'understanding.'

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* Here we are constrained to forego the employment of the language of Gautama, who says that "Earth, Water, Light, Air, Ether,—these are the 'Elements' (*bhúta*)." What may be said for and against the theory that there are five special substrata for the qualities which affect the five senses, we may have occasion to consider further on. In the mean time, to denote 'external things' we may employ the term *bhútádi*, i. e., 'the elements &c.,' meaning by the '&c.' whatever is compounded of the elements.

Aphorism XV.

Understanding (*buddhi*), apprehension (*upalabdhi*), knowledge (*jnána*),—these terms are not different in meaning.

a. 'Not different in meaning'—i. e. synonymous.

b. 'Next we have to characterise the Mind.

Aphorism XVI.

The characteristic of the Mind is this, that there does not arise [in a single Soul] more than one cognition at once.

a. 'At once'—i. e., simultaneously. Of course you must supply 'in a single soul.'

b. The sense of the Aphorism is this, that the sign, or characteristic, whereby we recognise the mind (or the internal organ of the Soul), is the habit in virtue of which more thoughts than one do not occur at once.*

c. We have next to define Activity.

Aphorism XVII.

Activity is that which originates the [cognitions of the] understanding and the [gestures of the] body.

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* The English reader who is accustomed to hear the words Soul and Mind employed interchangeably must avoid all such laxness of phraseology when speaking with a Hindú metaphysician. We shall have occasion in the sequel to compare the opinion of Gautama with that of Dugald Stewart respecting the non-simultaneousness of cognitions. Meantime let it be carefully remembered that the cognizant principle is here spoken of as the Soul, and that the term Mind (*manas*) stands for the 'internal organ,' or faculty, which ministers to the Soul—or Self—as the 'external organs' also minister to it,

a. Thus activity (*pravritti*) is of two* sorts, through its setting the Understanding to work or the Body.

b. It is also divisible into two kinds through the distinction of proper and improper.†

c. We have now to define the Passions.

Aphorism XVIII.

[The Passions] Desire &c. have this characteristic, that they actuate.‡

a. 'That they actuate'—i. e., that they are causes of Activity Desire &c., are what are distinguished by being such. The meaning of the '&c.' will be told in the sequel.

b. We have now to define mundane life.

Aphorism XIX.

[Mundane] life is the union of the soul with such bodies as we have here.§

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* Gautama makes it of three sorts, holding that to be a separate kind which originates the utterances of the voice. This we look upon as being included under the second head.

† With this distinction Gautama, for reasons given in our version of the first book of his Aphorisms, is not concerned. Not agreeing with him that *all* Activity is to be eschewed, we are called upon to mark the distinction. Of this more anon.

‡ Gautama, holding that all Activity ought to be eschewed, gives to all the passions, good and bad alike, the common name of 'faults' or 'failings' (*dosha*). Not being Quietists, we cannot follow him in this. We have modified the Aphorism accordingly.

§ Gautama defines life as a state of transmigration. This view we do not adopt. Our own definition is not at variance with Gautama's view, although we demur to the proposition that every one who is now born has been born again and again.

a. We have next to define the fruit of actions, or Retribution.

Aphorism XX.

The fruits of our actions are those things [whether pleasurable or painful] which are the consequences of our Activity.

a. That is to say, retribution is the experiencing of the pleasures or the pains which result from Activity properly or improperly directed.

b. Pain is next to be defined.

Aphorism XXI.

Pain is that which is in the shape of vexation.

a. That is to say, pain is that which is recognised by distress or annoyance.

b. We proceed next [not to define but] to show the Chief End of Man in conjunction with its cause.

Aphorism XXII.

The Chief End of Man is to be attained through the grace of God.

a Here we quit the topic of the definition of the things concerning which it is desirable that we should entertain right notions.

b. Now the bare enunciation and definition of the Objects,

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* Gautama defines the Chief End of Man to consist in absolute emancipation from pain and joy alike. For the discussion which that definition is calculated to provoke, this is not the place.

concerning which it is desirable that we should entertain right notions, does not ensure a correct knowledge and belief of them. Demonstration may be needed; and this is preceded by Doubt. We have now therefore to define the state intermediate between hearing and believing—or Doubt.

SECTION IV.

COMPLETING THE TOPIC OF THE PRE-REQUISITES OF REASONING.

Aphorism XXIII.

Doubt is [what results] from the perception of a sameness, [conjointly with] the non-perception of a difference, and the remembrance of a difference.*

a. That is to say,—Doubt arises 'from the perception of a sameness,'—i. e., from the apprehending of some concrete object which possesses characters common to it with other objects; and 'from the non-perception of a difference'—i. e. from the not discerning any character such as distinguishes the object from all other objects;—and 'from the remembrance of a difference,'—i. e., from the taking into consideration some special character—such as the fact of being a post or the fact of being a man—[the remembrance of which alternatives keeps up the doubt so long as there is nothing to enable us to decide, in the dusk for instance, whether the object which appears to be of the height of a man is a man or a post].

* We have taken this definition from *Kanáda* (2d Lecture), because it is simpler than that given by Gautama, in regard to the interpretation of whose 23d Aphorism (—See the English version—) the commentators are not agreed.

b. Now, since one makes no effort for the removal of doubt in the absence of a motive, we have next to define a Motive.

Aphorism XXIV.

That thing which, when placed before us, causes us to act, is a Motive.

a. 'Placed before us'—i. e. proposed to us. So the meaning is this, that a motive is an object of desire, which [—whether the desire be to obtain it or to escape it—] is the cause of our acting.

b. But, in every enquiry, to reach the unknown we must start from the *known*;—there must be *data*. The knowledge which, in any enquiry, we may treat as requiring no demonstration, is either popular—being that on which the unlearned and the learned are at one;—or it is scientific—belonging to the schools. First then we have to define a popular datum or 'familiar case of a fact.'

Aphorism XXV.

In regard to [some fact respecting] what thing both the ordinary man and the acute investigator entertain a sameness of opinion, that [thing] is called a 'familiar case' [of the fact in question].

a. Here, by 'the ordinary man' we mean the one who stands in need of instruction, and by the 'acute investigator' one competent to instruct him. Whatever thing they entertain a 'sameness of opinion'—i. e., no difference of opinion—regarding, that thing may serve as a 'familiar case' (*drishṭánta*) in regard to any fact that may be under discussion. So, what we mean to be understood by a 'familiar case of a fact' is anything in regard to which both the parties in a dispute are agreed that there is no doubt,—

as, for example, in proving that there is fire in such and such a place, the *culinary hearth* will be accepted by every one [in India] as a familiar case of a locality where there is always fire ; and in proving that there is *not* fire in such and such a place, a *deep lake* will be admitted to be a familiar case of a locality where fire is *not* to be met with.

b. Here closes the topic of the pre-requisites of reasoning [—for, although scientific data—see Aph. 24. *b.*—are available, in the schools, as premises, yet they were first established by a process of argumentation].

c. We have next to define a scientific 'tenet.'

SECTION V.

OF PROPOSITIONS, NOT FAMILIAR, THAT MAY BE EMPLOYED IN REASONING WITHOUT REQUIRING TO BE EACH TIME DEMONSTRATED.

Aphorism XXVI.

A 'tenet' is that, the steadfastness of the acceptance of which rests on a treatise [of weight and authority].

a. That is to say,—a tenet is an assured conviction in respect of some matter which has been determined in some system.

b. We have next to divide [the 'tenets' thus characterised generally].

Aphorism XXVII.

[Tenets are divided into the species that are described in the succeeding aphorisms] through the difference between a 'Dogma of all the schools,' a 'Dogma peculiar to some one or more

schools,' a 'Hypothetical Dogma,' and an 'Implied Dogma.'

a. Thus scientific tenets are of four kinds. First then we have to define a 'Dogma of all the schools' (*sarva-tantra-siddhánta*).

Aphorism XXVIII.

That [position or tenet] which is not in opposition to any of the schools, and which is advanced [as a tenet] by [at least] some one school, is [what we mean by] a 'Dogma of all the schools.'

a. Such a tenet of all the schools, or of all systems of doctrine, is the fact that *odour* is to be apprehended by the sense of *smell*, and so on.

b. We have next to define a 'Dogma peculiar to some school' (*prati-tantra-siddhánta*).

Aphorism XXIX.

That [position] which is [held] established in the same school, and which in another school is [regarded as] not established, is [what we mean by] a 'Dogma peculiar to some school.'

a. By 'established in the *same* school' we mean established in *one* school and not in another. A dogma is said to be of this kind—or sectarial, not catholic—when it is accepted by only one of the parties in a dispute. Such, for example, is [at present] the European tenet of the earth's motion.

b. The next to be defined is the 'Hypothetical Dogma' (*adhikaraṇa-siddhánta*).

Aphorism XXX.

That, if which be [held] established, [—and not otherwise—]

there is the establishing of another point, is [what we mean by] a 'Hypothetical Dogma.'

a. The meaning is this—that, that position [—for which no evidence is offered in the first instance—] is a hypothetical dogma [or hypothesis] only on the establishment of which taking place [—by its being conceded—] does the establishment take place of another proposition under consideration. For example,—you can establish that God is *omniscient* only when you have established that the world was *produced* [—for unless this be conceded, it is in vain to argue that the world furnishes any evidence of the omniscience of its *producer*].

b. Lastly we have to define an 'Implied Dogma' (*abhyupagama-siddhánta*).

Aphorism XXXI.

The mention of some particular character [which mention, by the leader of a school, could have arisen only] from his having held some opinion which he has not anywhere explicitly declared, determines an 'Implied Dogma.'

a. That is to say,—an 'Implied Dogma' is determined by the mention of some particular fact, by which we are made aware that the teacher held some opinion which he did not explicitly declare. Thus, for example, Gautama [by speaking of the Mind as one of the *instruments* of knowledge] implies that he reckons the Mind among the *organs* [of the Soul, although he nowhere explicitly lays down this tenet, which is a tenet not held, for instance, by the followers of the *Sánkhya* school].

Here ends the topic of the definition of 'tenets' that take their place in argumentation.

We have next to divide—previously to defining—the Mem-

bers [of a demonstration] which present themselves next in order [of the topics enumerated in the first aphorism].

SECTION VI.

THE METHOD OF ARGUMENTATIVE EXPOSITION.

Aphorism XXXII.

The members [of a demonstration] are (1) the Proposition, (2) the Reason, (3) the Example, (4) the Application, and (5) the Conclusion.

a. Now we have to define the Proposition (*pratijña*).

Aphorism XXXIII.

The Proposition is the declaration of what is to be established.

a. That is to say,—the member [of an argumentative exposition] in which we state what we intend to prove, is the Proposition. For example—"The Earth is in the form of a globe," is a Proposition [—what we here undertake to prove of the Earth being its *globularity*].

b. We shall next define, and, by [reference to] the two subsequent aphorisms, divide, the Reason (*hetu*), which presents itself next in order [of those enumerated in Aphorism 32].

Aphorism XXXIV.

The Reason is the means for the establishing of what is to be established; [and this force it may derive either] from the Example's having a character which involves another, or [conversely] through the Example's wanting a character the want of which involves the absence of another.

a. Here the generic definition is this—that 'the Reason is the means for the establishing of what is to be established.' That a Reason may be of *two* kinds, is declared in the assertion that it derives its force as an argument, (1) from the Example's having a character which involves another, or (2) from the Example's wanting a character the want of which involves the absence of another.

b. The 'having a character which involves another' (*sádharmya*) is what is also spoken of as 'Agreement' (*anwaya,*)—meaning thereby 'the fact of some positive character's being invariably attended by some other.' Thus then the Member [of an argumentative exposition] which [Member, or Minor Premiss, as well as the Reason which it sets forth] is also technically spoken of as 'the Reason', may be that which propounds a Reason which stands in relation to a Universal Affirmative. For example, [we may assign as a Reason for the Proposition that 'The Earth is a globe'] the assertion—'Because its shadow [on the Moon] is [invariably] circular'—and [this we may allege as standing in relation to the Universal Affirmative that] 'whatever has an invariably circular shadow is seen to be a globe,—as is the case with a billiard-ball, for example.'

c. The 'wanting a character the want of which involves the absence of another' (*vaidharmya*) is what is also spoken of as 'Disagreement' (*vyatireka*),—meaning thereby 'the fact of some given negative character's being invariably attended by the negation of some other character.' Thus then the Member termed 'the Reason' [or Minor Premiss] may be that which propounds a Reason which stands in relation to a Universal Negative. For example, we may assign as a Reason, in support of the foregoing Proposition, the same assertion as before—viz., 'Because its shadow is invariably circular,' and [this we may allege as

standing in relation not as before to a Universal Affirmative but to the following Universal Negative, viz.,] "Nothing which is not a globe casts invariably a circular shadow,"—as a post, for instance.

d. We have now to define the 'Example' which presents itself next in order [of those enumerated under APH. 32].

Aphorism XXXV.

The Example is some [undisputed] 'familiar case of a fact' [see APH. 25], which, through its having a character which is invariably attended by what is to be established, establishes, [in conjunction with the Reason] the existence of that character which is to be established.

a. When we employ the term 'Example' to denote that third Member of a demonstrative exposition in which the actual Example is propounded, we mean by the term 'Example' that [Major] Premiss which causes us to admit the Subject's possession of what is to be proved, this being seen to follow from the possession of the instrumental mean [which we have already spoken of as the 'Reason']. For example—when it is alleged that every thing which invariably casts a circular shadow is globular—'as is a billiard-ball,' [which invariably casts a circular shadow,—the recognition of this fact causes us to recognise the globularity of the Earth—the Earth having been already allowed to possess the character of invariably casting a circular shadow].

b. [But the 'Example,' as already remarked, may be of two kinds; so that] we have now to define the Example in which some two given characters [instead of being both present] are both absent.

Aphorism XXXVI.

Or the Example, on the other hand, wanting some character the want of which involves the absence of some given character,

[may co-operate in establishing what is to be established] by a process the converse* of that [declared in the preceding aphorism].

a. 'By a process the converse of that'—i. e. by exhibiting the invariable absence of the alleged Reason where there is the absence of what is to be established. And thus an 'Example of concomitant negatives' (*vyatirekyudáharaṇa*) means one which [—conveyed in a Major Premiss consisting of a Universal Negative—] declares the invariable absence of the alleged Reason where there is the absence of the character the presence of which we wish to establish. For instance—'Nothing which is not a globe casts invariably a circular shadow,—as a post, for example, [—or as a circular disc, which, not being a globe, does not invariably cast a circular shadow, though it may do so in certain positions].

b. We have now to define the 'Application' (*upanaya*) which presents itself next in order [of those enumerated in Aphorism 32].

Aphorism XXXVII.

The 'Application' is the re-statement of that in respect of which something is to be established,—this re-statement declaring it to be *so* or *not so*, as regards the 'Example.'

a. By 'that in respect of which something is to be established,' we here mean the Subject of the Proposition. By the 're-statement as regards the Example,' we mean that Member [of an

* This refers to the "conversion by *negation*; or, as it is commonly called, by *contra-position*," of which Whately speaks in his Logic, B. II. ch. 2d. § 4., remarking that every Universal Affirmative may "be fairly converted in this way" *e. g.*, Every poet is a man of genius; *therefore* He who is not a man of genius is not a poet:" (or, "None but a man of genius can be a poet").

argumentative exposition] in which the Subject is declared to agree with the Example, or to differ from it, as far as regards the question in hand. This re-statement may assume two forms according as the Example is direct, or negatively converse. The re-statement of the Subject takes the form of—'And this is so' —when the re-statement has reference to a direct Example. Thus the re-statement may be 'And this Earth is so, [—when the Major Premiss involves a direct Example,—i. e., when it runs thus—'Whatever is possessed of a shadow invariably circular is a globe—as a billiard-ball is']. The re-statement in regard to the Subject takes the form of 'And this is *not* so,'—when the re-statement has reference to a negatively converse Example. [Thus the re-statement may be 'And this Earth is *not* so'—when the Major Premiss involves a negatively converse Example;—i. e., when it runs thus—'whatever is not globular is not possessed of a shadow invariably circular,—as a post, for example;'—but 'this Earth is *not* so,' for the Earth *has* a shadow invariably circular].

b. We have now to define the 'Conclusion' (*nigamana*).

Aphorism XXXVIII.

The 'Conclusion' is the re-statement of the 'Proposition' [as being now authorized] by the mention of the 'Reason.'

a. The 'mention of the Reason'—i. e. the mention [—involved in the steps between the Proposition and the Conclusion—] of a character of the Subject which is distinguished by being invariably attended [by that which we wish to establish]. This re-statement of the Proposition—authorized thereby—constitutes the Member [of an argumentative exposition] which we mean by the 'Conclusion.' For example, [our conclusion may be] 'Therefore [—i. e. for that Reason—] the Earth is a globe.'

b. Here concludes the topic of the method of argumentative exposition.

c. But, thus far, we have been shown an arrangement for hearing only one side of the question, and how can we be sure that the opposite is not the right one? Before making up our minds we must hear both sides. Next, therefore, before defining 'Ascertainment' we have to define the 'Confutation' (*tarka*) of objections.

SECTION VII.

CONCLUDING THE TOPIC OF DEMONSTRATION.

Aphorism XXXIX.

'Confutation'— [which is intended] for the ascertaining of the truth in regard to any thing the truth in regard to which is not thoroughly discerned—is reasoning from the presence of the reason [which would not be present if that which is to be established were not present].

a. [In other words, the confutation of him who denies the conclusion of a sound argument while he admits the premises, consists in our directing him to look at it from an opposite point of view. To one who admits that the Earth's shadow on the Moon is invariably circular, and that what casts a shadow invariably circular must be a globe, but who still hesitates to admit that the Earth is a globe, we remark]—for example—'If the Earth were *not* a globe, it would not have a shadow invariably circular.'

We have now to define 'Ascertainment' (*nirṇaya*) which presents itself next in order.

Aphorism XL.

'Ascertainment' is the determination of a matter by dealing with both sides of the question, after having been in doubt.

a. That is to say—'Ascertainment' is the settling of the question by the establishing of the one view of it and the confuting of the other view.

b. Here ends the first diurnal portion of the first Book.

c But an honest enquirer after truth may have heard both sides and still be in perplexity. Amicable 'Discussion' (*váda*) is then open to him; and this we proceed to define.

THE SECOND DIURNAL PORTION.

SECTION VIII.

THE TOPIC OF CONTROVERSY.

We have now to define amicable 'Discussion' (*váda*).

Aphorism XLI.

'Discussion' is the undertaking [—by two parties respectively—] of the one side and of the other in regard to what [conclusion] has been arrived at by means of the five-membered [process of demonstration already explained;—this discussion] consisting in the defending [of the proposition] by proofs [on the part of the one disputant] and the assailing it by objections [on the part of the other,—the discussion being conducted on both

sides] without discordance in respect of the tenets [or principles on which the conclusion is to depend].*

a. Since those who, (under the pretence of seeking the truth,) are dishonestly eager for victory, will *wrangle,* we have next to define 'Wrangling' (*jalpa*).

Aphorism XLII.

'Wrangling,' consisting in the defence or attack [of a proposition] by means of 'Frauds' [—see *Aph.* 50—], 'Futilities' [—see *Aph.* 58—], and 'What calls for nothing save an indignant rebuke' [—see *Aph.* 59.—], is what takes place after the procedure aforesaid [—that is to say after a fair course of argumentation,—supposing this to have failed to bring the disputants to an agreement].

a. So—what we mean by 'Wrangling' is the discourse of one bent only on victory, and indifferent which side of the question is established, provided he secure the credit of a victory.

b. Disingenuous persons who have not sufficient skill for 'Wrangling' [—which implies the possession of sufficient skill to take up a position and maintain it—], have recourse to *cavilling.* We have next, therefore, to define 'Cavilling' (*vitaṇḍá.*)

Aphorism XLIII.

This [—viz., 'wrangling'—], when devoid of [any attempt made for] the establishing of the opposite side of the question, is 'Cavilling.'

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* The reader who collates the English version with the Sanskrit will observe that here, as in various other places, explanatory clauses are inserted in the English version of the Aphorism instead of being subjoined to the Aphorism, as is customary in Sanskrit works.

a. That is to say,—when a disingenuous disputant, eager for victory, attempts to establish nothing, but confines himself to carping at the arguments of the other party, he is said to cavil.

b. Here the topic of 'Controversy' is concluded.

c. Now, wranglers and cavillers, when they do not find good reasons to support their positions, make use of what merely *look* like reasons;—and even the honest enquirer, by mistake, may make use of such;—therefore we now procede to define and divide the 'Semblance of a reason' (*hetwábhásá*) which presents itself next in order [of the topics enumerated in the first Aphorism].

SECTION IX.

OF FALLACIES, OR WHAT ONLY LOOK LIKE REASONS, BY MEANS OF WHICH A MAN MAY DECEIVE HIMSELF OR ANOTHER.

Aphorism XLIV.

The 'Semblances of a reason' are (1) the 'Erratic,' (2) the 'Contradictory,' (3) the 'Equally available on both sides,' (4) that which is 'In the same case with what is to be proved, and (5) the 'Mistimed.'

a. By the 'Semblance of a reason' we mean a mere appearance which is *like* a reason, or, in short, a *bad* reason.

b. Of this class we proceed to define the first, viz., the 'Erratic' (*savyabhichára*).

Aphorism XLV.

That [semblance of a reason] is 'Erratic' which attends not

merely the one [character, which it is employed to prove, but attends also the absence of that character].

a. This 'Erratic' semblance of a reason may be subdivided, as we shall have occasion to see in the sequel.

b. We have now to define the 'Contradictory' (*viruddha*) semblance of a reason, which comes next in order.

Aphorism XLVI.

That [semblance of a reason] is called 'Contradictory' which is repugnant to what is proposed to be established.

a. In other words,—after having proposed, or stated, that which is to be proved, a 'Contradictory' semblance of a reason is one employed which is opposed thereto, or invariably attended by the *negation* of what is to be established :—as if, for example, one were to argue "This is fiery,—because it is a body of water."

b. We have now to define that semblance of a reason which is 'Equally available on both sides' (*prakaraṇasama*),—this presenting itself next in order.

Aphorism XLVII.

That [pretended reason] from which a question may arise as to whether the case stands this way or the other way, if employed with the view of determining the state of the case, is 'equally available on both sides' [of the dispute].

a. That is to say ;—that reason employed, or adduced, for the ascertainment of one's own proposition, or the negation of the other's proposition, is called 'the same for both sides' :—but *which* reason ?—that from which two opposite views may arise [—so that nothing is settled by it at all].

b. For example,—suppose a man argues that Sound is eternal, because it has the nature of Sound, his opponent will be provoked to retort that Sound is *not* eternal, just because it has the nature of Sound,—the argument having just as much force on the one side as on the other.

c. We have now to define that semblance of a reason which is 'In the same case with what is to be proved' (*sádhyasama*),—this presenting itself next in order.

Aphorism XLVIII.

And it [—the alleged reason—] is 'In the same case with what is to be proved,' if, in standing itself in need of proof, it does not differ from that which is to be proved.

a. If the reason stands in need of being proved too, just as the proposition stands in need of being proved, then it is said to be in the same case with what is to be proved, and therefore the expression 'unestablished' (*asiddha*) is employed in speaking of such a reason. And this 'unestablishedness' or 'unreality' is of several descriptions, as will be seen in the sequel.

b. We have now to define the 'Mistimed' (*kálátíta*) semblance of a reason,—which comes next in order.

Aphorism XLIX.

That [semblance of a reason] is said to be 'Mistimed' which is adduced when the time is not [that when it might have availed].

a. For example,—suppose one argues that fire does not contain heat 'because it is factitious,'—the argument is 'Mistimed' if we have already ascertained, by the superior evidence of the senses, that fire [—granting it to be factitious—] *does* contain heat.

b. Here concludes the topic of the Semblance of a reason.

c. We remarked that an honest enquirer may, inadvertently, take the semblance of a reason for a real one; but what we have next to define are the tricks which are employed only by the dishonest disputant.

SECTION X.

OF THE TRICKS EMPLOYED BY THE DISHONEST DISPUTANT TO THWART THE OTHER PARTY.

Aphorism L.

'Unfairness' (*chhala*) is the opposing of what is propounded by means of assuming a different sense [from that which the objector well knows the propounder intended his terms to convey].

a. We proceed to enumerate the divisions of 'Unfairness.'

Aphorism LI.

It [—viz., 'Unfairness'—] is of three kinds, (1) Fraud in respect of a term, (2) Fraud in respect of a genus, and (3) Fraud in respect of a trope.

a. Of these we shall now define 'Fraud in respect of a term' (*vák-chhala*).

Aphorism LII.

'Fraud in respect of a term' is the assigning a meaning other than [the objector well knows] was intended by the speaker when he named the thing by a term that happened to be ambiguous.

a. For example,—if some one says "A cow (*gau*) has horns,'—a caviller, recollecting that the word *gau* is explained in the dictionary to mean an elephant as well as a cow, may exclaim—

"What!—do you say that an *elephant* has horns?"

b. We have next to define 'Fraud in respect of a genus' (*sámányachchhala*).

Aphorism LIII.

'Fraud in respect of a genus' is the assuming that something is spoken of, in respect whereof the fact asserted is impossible, because [forsooth] this thing happens to be the same in *kind* with that of which the fact asserted *is* possible.

a. For example, on some one's saying, 'This is a 'Bráhman,' —he must be possessed of learning and conduct';—the other, assuming that he here deduces the possession of learning and conduct from the fact of being a Bráhman, says—'How can that 'be?—for, the possession of learning and conduct, if deducible 'from the fact of being a Bráhman, would be found, where it 'cannot, in his *childhood*.' [The other, of course, meant, as the objector very well knows, to speak of a Bráhman who has lived long enough in the world to render it possible for him to study, in which case the probability is that he will have studied].

b. We have next to define 'Fraud in respect of a trope' (*upacháráchchhala*).

Aphorism LIV.

'Fraud in respect of a trope' is the denial of the truth of the matter, when the assertion was made in one or other of the modes, [viz., literal or metaphorical,—which it suits the purpose of the objector to invert].

a. For example, in the case of such an assertion as 'The scaffolds cry out' [—somewhat analogous to the English phraseology 'The pit and gallery applauded'—] a dishonest opponent will say 'It is only *those standing* on the scaffolds that cry out' [—as if the

other had meant to make the assertion literally of the scaffolds.

b. Here it may be proper to anticipate an objection.

Aphorism LV.

'Fraud in respect of a trope' [some one may fancy at first sight—] is just 'Fraud in respect of a term,' for it does not differ therefrom.

a. The meaning of this objection is, that Fraud is of only two kinds, not of three kinds; for Fraud in respect of a trope is just Fraud in respect of a word, seeing that these agree in the assumption that some word was employed in another sense than that in which it was well enough known that the speaker did employ it.

b. This objection we proceed to overrule.

Aphorism LVI.

It is not so [as the objector in Aphorism 55 supposes,] because they *do* differ.

a. To show that the opposite view involves an absurdity we remark :—

Aphorism LVII.

Or if there were no distinction where there is *any* similarity of character [—as there no doubt is between the two species of Fraud under consideration—] then we should have only *one* kind of Fraud.

a. That is to say,—if no distinction is to result from any property whatever provided there be *some* similarity of nature, then 'Fraud', in as much as each variety has a common nature so far forth as each *is* a 'Fraud,' would not be even of *two* kinds, as the objector is understood to hold that it is.

b. Here concludes the topic of Fraud in disputation.

c. We have now to define 'Futility,' which presents itself next in order.

SECTION XI.

OF FUTILE OBJECTIONS AND HOPELESS STUPIDITY.

Aphorism LVIII.

Futility consists in the offering of objections founded on[some mere] similarity or difference of character [—without regard to the question whether the fact asserted bears any invariable relation to that character].

a. The expression 'founded on similarity or difference of character' is a definite one [—intended to convey just so much, and to exclude everything beyond—] : therefore the meaning is this, that Futility consists in objecting, or taking exception, on the ground of similarity or difference of character *without respect to invariableness of association* [between the character and that whereof it is taken as a sign of the presence or the absence. For example, if it were propounded that 'The man is unfit to travel, because he has a fever,' it would be futile to object that 'The man *is* fit to travel, because he is a soldier'—there being no invariableness of connection between the being a soldier and the being fit to travel].

b. We have now to define 'Unfitness to be argued with' (*nigrahasthána*),—the topic which presents itself next in order.

Aphorism LIX

Unfitness to be argued with consists in one's [stupidly] misunderstanding, or *not* understanding at all.

a. The term here rendered 'Unfitness to be arguedwith ' signifies literally the place, i. e. the suggester, of censure or rebuke: [—for if a man stupidly misunderstands you or does not understand you at all, and yet still persists in trying to make a show of opposition, then the matter has come to that point where there is nothing left for it but to rebuke him and drop the discussion].

b. In order to prevent the mistake, [into which some might fall, of supposing] that there is no subdivison of Futility and Unfitness to be reasoned with, [—the subdivisions of which will be stated in their proper place—] we remark as follows.

Aphorism LX.

Since each of them is of different kinds, 'Futility' and Unfitness to be reasoned with' are of various descriptions [which will be considered in the sequel].

a. But, as other questions are more pressing, their subdivision is not made at present:—such is the import of the Aphorism.

END OF THE FIRST BOOK.

BOOK II.

SECTION I.

OF THE FIVE SENSES.

In the 1st Book* the Senses and their Objects were enumerated. Now each of these is to be described more fully; and first of the Sense of Smell† (*ghrâṇa*).

Aphorism I.

The organ of Smell resides in the nose.

a. Particles issuing from odorous bodies and drawn into the

* In the second and subsequent Books we do not follow the order of Gautama's second and subsequent Books. His first Book contains the germs of his whole philosophy. Having re-written the first Book, we proceed to develope its germs in the order that seems most likely to lead on the understanding from the point reached to the point which we desire to reach.

† Reid (—see Sir Wm. Hamilton's edition, p. 104) says that the principle of proceeding, in an exposition, from the more simple to the more complex, "ought to determine us to make choice even among the senses, and to give the precedence, not to the noblest or most useful, but to the simplest." Gautama follows, to some extent, the same order as Reid, but for a different reason, his arrangement of the five senses being determined by the order in which he discusses his five Elements—his five substrata of the qualities apprehended by the senses respectively. Among his Elements, he gives the precedence to that which he holds to possess the greater number of sensible qualities.

nose in breathing, come into contact with the organ, and then, in the absence of preventing causes, the sensation of smell takes place.

b. Hence that body is called odorous in which there resides such a quality or power* that when its particles come into contact with the organ of smell, in the absence of preventing causes, the sensation of smell takes place.

c. Next of the sense of Taste (*rasana*).

Aphorism II.

The organ of Taste resides in the tongue.

a. Particles of sapid bodies taken into the mouth, and dissolved in a fluid such as the saliva, come into contact with the organ, and then, in the absence of preventing causes, the sensation of taste takes place.

b. So, that body in which resides the power of producing such a sensation is called sapid.

c. Next of the sense of Sight (*chakshush.*)

Aphorism III.

The organ of Sight resides in the eye.

a. Light comes to the eye from bodies either self-luminous or illuminated, and then, in the absence of preventing causes, the sensation of sight takes place.†

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* This assertion is designed as a demurrer to the dogma of the Nyáyá that Odour belongs only to an Element called Earth (*prithivi*), and that everything that is odorous is therefore earthy.

† Here we oppose the Nyáya theory that a ray *goes* from the eye to the object.

b. Of the nature of Light, and its relation to Colour, and of the structure of the Eye, we shall have occasion to treat in the sequel.

Next of the sense of Touch (*twach*).

Aphorism IV.

The sense of Touch, by which the tangible is apprehended, distributed throughout the whole body, is particularly delicate at the tips of the fingers; for it is chiefly in the fingers that there resides the power of ascertaining, by touch, the number and magnitude [of small objects*].

a. Next of the sense of Hearing (*s'rotra*).

Aphorism V.

The sense of Hearing is lodged in the ear.

a. What is it that is apprehended by this sense? To this we reply;—that the sensation of *sound* takes place when a membrane in the ear [—the tympanum—] vibrates in a manner adapted to the sense of Hearing.† Of the nature of sound, and of the structure of the ear, we shall have occasion to treat in the sequel.

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* For example,—if the points of a pair of compasses are separated to about the tenth of an inch, their separateness and their distance can be distinctly appreciated by applying them to the tip of the finger, but not by applying them to the cheek.

† Thus we demur to the theory that Sound is a *Quality* residing in an all-pervading Element called the Ether, and that it may be therefore at all times in a sonorous body, whether perceived or not.

SECTION II.

OF THE OBJECTS OF THE SENSES.

c. Now we shall make some remarks on the *Objects* of the Senses, the first of which, in the enumeration given in Aph. XIV. Book I., is Odour (*gandha*).

Aphorism VI.

The quality of Odour is that power belonging to certain substances whereby the sensation of Smell arises when the particles of such a substance come into contact with the Organ of Smell.

a. As there is no proof that whatever possesses Odour must be of one particular kind of substance—viz. of Earth—, and as there appears to be no advantage in holding such an opinion as a hypothesis, we shall simply speak of anything as being odorous from which we derive the sensation of Smell, whether it be solid or fluid. On this point we shall have occasion to speak further in the sequel*.

b. Next of the quality of Savour (*rasa*).

Aphorism VII.

The quality of Savour is that power belonging to certain substances whereby the sensation of Taste arises when the particles of such a substance come into contact with the Organ of Taste.

a. As pure Water, in our opinion, has no taste, we differ from those who say that it has a sweet taste; but we hold that Water, in the shape, for example, of the saliva, though itself without taste, conduces to the production of the sensation

* When we come to the subject of Chemistry.

by dissolving sapid bodies so as to bring their particles into contact with the Organ of Taste.

b. Next of the quality of Colour (*rúpa*).

Aphorism VIII.

The quality of Colour is the power, belonging to certain kinds of substances, to affect Light in such a manner that when the Light comes in contact with the Organ of Sight the sensation of Colour takes place.

a. What modifications Light is liable to, when it comes into contact with various substances, will be considered in the sequel.*

b. Now, as we talk of seeing a white cow or a green tree, so we talk of seeing a *distant* tree or other object. Do we, then, *see* distance as we see colour? On this point we proceed to remark:—

Aphorism IX.

The Distance of an object is not seen, but is inferred from the indistinctness of the object and our knowledge of its character, &c.

a. 'Of an object',—i. e. of any perceptible object,—the distance 'is not seen'—i. e. is not directly perceived. How then is it *known?* To this we reply 'but it is inferred,'—or is learned by inference, from its indistinctness &c. In short the knowledge of distance is due to a general proposition, viz., that in general what is near appears distinct, and what is distant appears indistinct, as is the case with a large tree in the distance, seen through a very small window which occupies a larger space in the field of

* When we come to the subject of Optics.

vision than the tree does. Here the tree is not really the smaller of the two, though it *appears* to be so; and so, from its indistinctness &c. its distance is inferred. The sun is ninety millions of miles distant, but the sun is not indistinct; and therefore, though it is immensely larger than the earth, it appears to the eye to be at no great distance, and smaller than a potter's wheel.

b. By the '&c.' in the aphorism, we refer to the apparent smallness of an object which we know antecedently to be large. Ignorance of the cause of the indistinctness of an object gives rise to mistaken notions of its size and distance. Thus, in a fog, or when the light is failing, a crow close at hand may be mistaken for a distant elephant, if we do not advert to the cause of the indistinctness*.

b. Next of the quality of Tangibility (*sparśa*).

Aphorism X.

The quality of Tangibility is the power belonging to certain kinds of substances to produce the sensation of Touch when they are brought into contact with the organ of Feel which resides in the fingers &c.

a. Next of the quality of (*śabda*) Sound (or rather Sonorousness).

Aphorism XI.

The quality of Sonorousness is the power of occasioning such vibrations as produce the sensation of Hearing when they are communicated to the tympanum of the ear.

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* Cf. Reid's collected works, p. 191.

a. The vibrations of a sounding body are communicated to the tympanum by means of some medium, such as the air, as will be explained in the sequel.*

b. Now, as we talk of hearing a harsh sound or a soft sound, so we talk of hearing a *distant* sound. Do we then *hear* the distance as we hear the sound ? On this point we proceed to remark :—

Aphorism XII.

The Distance of a sounding body is not heard, but is inferred from the character of the sound and our knowledge of the sounding body.

a. A sound, to one near the sounding body, appears louder than a like sound to the same person when at a greater distance. The sound of a waterfall in the Himálayas, while it continues the same to a person so long as he remains standing near it, becomes less and less as he moves away from it; so that, recollecting the force of the sound when he stood near it, he can form some estimate of its distance, when he perceives the force of the sound to be more or less diminished. So, on the other hand, when we know that the cause of a sound is very distant, we infer that the sound is much greater than it appears. For example, when we know that a certain sound has arrived from a distance of ten miles, we probably infer that it is the sound of a cannon, though it may not appear so loud as that of a musket fired near us. Hence, again, when we know neither the distance nor the nature of the cause of the sound, we may confound the thunder of a distant cloud with the rumbling of a neighbouring cart.

b. Now the substances which affect the senses by means of

* When we come to the subject of Acoustics.

these five powers or qualities, may be regarded in two ways, as we proceed to explain.

SECTION III.

OF MATTER, OR THAT THE QUALITIES OF WHICH FURNISH THE OBJECTS OF THE SENSES.

Aphorism XIII.

Substances which affect the senses (i. e. material substances,* or matter,) may be regarded as being either in the shape of Atoms or of Masses.

a. We shall consider Atoms in the sequel.† In the meantime we proceed to divide Matter as it occurs in mass.

* Of such substances the Nyáya reckons five—its five Elements (*bhúta*). As the term 'Element' is not equivalent to the term 'Matter',—not being applicable to composite material masses such as trees, human bodies, &c.; and as there is no other term common to the five which is not at the same time common to things *not* material, it follows that the philosophical terminology of the Nyáya offers no term co-extensive with the term Matter. No practical inconvenience, however, need result from this, if the fact be carefully kept in mind—along with the exact reasons why the fact is so. That this is the case it will be our business to endeavour to show as we proceed. 'Material things', in the present section, are rendered *bhautika-padártha* i. e. 'things formed of the Elements.'

† When we come to the question of the Constitution of the Masses.

Aphorism XIV.

Matter viewed in mass, may be divided into this Earth with its inhabitants, and the rest of the material universe.

a. In accordance with this division we may define the province (or the object-matter) of Astronomy as follows.

Aphorism XV.

The positions and motions &c. of the rest of the material universe (—the sun &c.—), viewed in connection with the Earth regarded as a unit, constitute the object-matter of Astronomy.

a. As the reader may be curious to learn the opinions of Europe on the subject of Astronomy, we shall give an outline of these before proceeding further with the division of the province of the sciences.

SECTION IV.

OF THE FACTS OF ASTRONOMY.

b. The first point here to be attended to is a two-fold division of the heavenly bodies, which we may state as follows:—

Aphorism XVI.

These may be divided into two sets,—for there are some that shine by their own light, and some that shine by a borrowed light.

a. That is to say—these heavenly bodies are of two kinds:—why ?—because some of them, as the fixed stars, shine by their own light as the sun does ; while others, as the planets, shine by a borrowed light, as the moon does by that of the sun.

b. If it be asked—why, then, do not the planets change their aspect as the moon does ?—we reply that they *do* change their aspect, as the moon does, to one so placed as to observe the change ; and, although this change is not discernible by the naked eye, yet by the aid of the telescope it is easily rendered evident in the case especially of the planet Venus.*

c. Next we have to declare the figure of the Earth.

Aphorism XVII.

The Earth is a globe.

a. One proof of this is exhibited in the chapter on Demonstrative Exposition in the first Book. Other proofs will be referred to in the sequel. That the Earth is a globe, has been shown by BHÁSKARA ÁCHÁRYA in his *Goládhyáya.*

b. Now, as regards the motion of the Earth ;—

Aphorism XVIII.

The Earth's rotation on its axis produces the alternation of day and night, whilst its annual revolution round the sun produces the change of the seasons.

a. Why then does the Sun appear to move round the Earth ? The Sun appears to move round the Earth just as, to children in

* The pandits of Benares have had an opportunity of seeing this by means of the College telescope taken into the city for the purpose.

a boat which is receding *from the bank*, the bank appears to recede *from the boat*. So ĀRYYA BHAṬṬA says, "As he who stands in a moving ship sees the mountain approaching him in the opposite direction, so does the inhabitant of Ceylon see the fixed stars wending toward the West." Proofs of the fact that the Earth moves round the Sun, will be given in the sequel.

b. Now, as regards the motion of the Moon.

Aphorism XIX.

The Moon moves round the Earth.

a. This is evident. Now, how and when do eclipses take place? In regard to this we have to declare as follows :—

Aphorism XX.

When the moon, revolving round the earth, comes between the Sun and the Earth, then there is an eclipse of the Sun; and when the Earth comes between the Sun and Moon, then there is an eclipse of the Moon.

a. As the Moon moves round the Earth once in a month, it might be expected that eclipses should occur once in a month. Why this does not happen will be explained in the sequel.

b. Now, as regards the motions of the Planets.

Aphorism XXI.

The Planets move round the Sun.

a. Why, then, it may be asked, do they not appear to do so? One reason is because the Earth also moves round the Sun; and therefore the Planets, as viewed from the Earth, do not appear to move in such paths as it is ascertained by calculation that they really do move in.

b. As the earth is attended by a Moon, it might be expected that the other Planets also should be attended by moons. In regard to this, we have to state that the planets which are nearer the Sun than the Earth is, have no moons, but some of the more distant planets are furnished with several. With regard to the number of moons attending these we have to remark as follows :—

Aphorism XXII.

The planet Jupiter has four moons ; and the planet Saturn, besides seven moons, is attended by a large luminous ring surrounding him.

a. Saturn's ring is not clearly discernible without a telescope.

b. By the telescope, myriads of stars, in addition to those visible to the naked eyé, are rendered visible. Thus the nature of the Milky Way has been discovered, in regard to which we have to remark as follows :—

Aphorism XXIII.

The Milky Way is nothing else than a conglomeration of stars.

a. Other facts regarding Astronomy, not mentioned here or in the sequel, will be found stated in the astronomical treatise of Pandit Bápú Deva.

b. Reverting to the division indicated in the 14th and 15th aphorisms of the second Book, we shall now consider the Earth with its inhabitants not as a partial unit in a system but as a system in itself.

Aphorism XXIV.

The Earth may be considered either as to its surface arrange-

ment, or its constituent masses, or the causes of the existing arrangement; and this gives rise to a three-fold division of the subject.

a. We have first, then, to give some account of the surface arrangement of the Earth.

SECTION V.

OUTLINES OF GEOGRAPHY.

Aphorism XXV.

The arrangement of the Earth's surface furnishes the object-matter of the science of Geography.*

a. The surface of the Earth is made up of sea and land, with mountains, rivers, cities, &c.; and the science that is concerned about the relative situations of these is Geography.

b. Now, rivers do not accomodate their courses to the positions of cities, but large cities are generally built, for the sake of water, on the banks of rivers,—as the city of Benares on the bank of the Ganges. Mountains, again, are not distributed according to the course of rivers, but the rivers take their course in accordance with the distribution of the mountains. With the view of explaining how this happens, we first remark as follows:—

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* The science of the Earth's surface—*bhú-prishtha-vidyá*.

Aphorism XXVI.

The flowing of rivers is dependent upon mountains, and it is by the arrangement of the mountains that the courses of the rivers are determined.

a. Under the term 'mountains' we here include all high grounds. Great rivers like the Ganges, take their rise in great mountain-chains, like the Himálaya. In explanation of the fact that great rivers take their rise in great mountain-chains, we have to state what follows.

Aphorism XXVII.

The tops of lofty mountains are cold, and there is a limit beyond which if a mountain rises it is always covered with snow from that limit to the top.

a. This limit, which is called the 'snow-line' or the 'limit of the snows' (*hima-símá*), differs in height, in different countries, according to the heat of the climate. In the Himálaya mountains (on the southern face) it is about 16,000 feet above the level of the sea. In the south of Europe, where the climate is colder than that of India, the line of perpetual snow is only about 1000 feet above the level of the sea; while, near the poles, snow covers the land down to the water's edge.

b. A natural consequence of a river's taking its rise in a snowy range next requires our notice.

Aphorism XXVIII.

Even when there is no fall of rain, those rivers which arise from the melting of the snow of lofty mountains become swollen in the hot weather.

a. This is observable in the Ganges at Benares, and the rea-

son of the increase of the water must be evident to those who reflect that the river comes from the melting of the snows of the Himálaya mountains.

b. As the Ganges is flooded during the summer, so too is the river Nile in Egypt. The following remarks relative to the cause of the flooding of the Nile are taken from the work of the Grecian historian Herodotus, who lived 427 years before Vikramáditya (B. C. 484).

c. "Concerning the nature of this river," says Herodotus, "I was not able to learn anything, from the priests or from any "one besides, though I questioned them very pressingly. For "the Nile is flooded for a hundred days, beginning with the "summer solstice; and after this time it diminishes, and is, "during the whole winter, very small. And on this head I was "not able to obtain anything satisfactory from any one of the "Egyptians, when I asked what is the power by which the Nile "is in its nature the reverse of other rivers. Yet there are "Greeks who, wishing to appear very wise, have offered three "explanations of the peculiarities of this river. Of these expla-"nations one is as follows:—That the north-wind, which blows "in the summer, is the cause of the rise of the river by pre-"venting it from discharging itself into the sea. But often it "has happened that the north-wind has not blown; yet the "Nile has risen as high as ever. Besides, if the north-wind were "the cause, it would follow that all rivers which flow against the "north-wind must exhibit the same effect; and so much the "more as their streams are feebler. But there are many rivers "exposed to this wind which undergo no such change as that "which takes place in the Nile.

d. "The second explanation is this that the rise of the Nile "happens because the Nile flows from the ocean, which, as they

" say, encompasses the whole earth. But as to what is here said " of the ocean, it is an obscure fable, destitute of proof. I know " of no such river as the Ocean. Homer, perhaps, or some of " the earlier poets, finding the name, transported it into the " language of poetry.

e. " The third explanation is this, that the overflow of the " Nile arises from the melting of snows. But now, how can it be " that a river which rises in Lybia, passes through Ethiopia, and " discharges itself in Egypt—thus proceeding from the hotter to " the cooler regions,—should owe its rise to snows? There are " many reasons which may convince any man that this cannot be " the case. In the first place—and it is a sufficient evidence to " the contrary—the wind that blows from these regions is hot. " Again, the men of those countries are blackened with the " heat. Besides, kites and swallows remain there through the " year, while cranes, flying from the Scythian winter, take up " their abode there during that season. But, of necessity, none " of these things would happen if, in the countries through " which the Nile runs, and where it takes its rise, snow fell even " in the smallest quantity."

f. From all this it is clear that Herodotus was not aware of the difference between the climate of high mountains and of the plains in a torrid region, which is declared in the 27th aphorism of this Second Book. Those, on the other hand, who are acquainted with this fact in regard to mountains, would at once infer, from the overflow of the Nile in summer, that the river takes its rise in a snowy range; and that it does so, just as the Ganges does, has now been ascertained by inspection.

g. Now, he who travels among the Himálaya mountains, and sees, one after another, innumerable peaks and innumerable streams descending from them, is apt to think that there is no

order or arrangement in the matter:—but if he takes a comprehensive view of the whole at once, he will see that there is a certain amount of uniformity in the arrangement throughout, the nature of which we now proceed to declare.

Aphorism XXIX.

The Himálaya range of mountains extends, East and West, along the North of India.

a. In this range there are various roads by which travellers can pass the mountains into the countries beyond. The line of snowy mountains in which these passes occur is therefore called "The Ghát-line of the snows"—[the word *ghát* meaning a pass].

b. Next, of the great peaks.

Aphorism XXX.

From the Ghát-line of the Himálayas, the highest peaks, with their attendant ridges, extend southwards.

a. Beginning with the peak of Jamnautrí, where the Ganges rises, and reckoning eastward, these southward-pointing ridges are those of Jamnautrí, Nandadeví, Dhawalagiri, Goswámisthána (or Gosa'ín-thán), Kanchangiri, Chamalárí, and the Gemini.

b. Next as regards the distribution of the rivers belonging to these.

Aphorism XXXI.

Between these ridges the numerous streams gradually unite to form a single river.

a. Between the ridge belonging to the peak of Jamnautrí, which is 25,669 feet high, and Nandadeví, which is 25,598, the streams flowing down from the melting snow, gradually converge in consequence of the concave form of the region; and thus, although there are many considerable hills between these two

ridges, such as the peak of Kedárnáth near Gangautrí, all the principal streams unite into one, and form the Ganges.

b. In like manner, between the ridge belonging to the peak of Nandadeví and that belonging to the peak of Dhawalagiri, many streams unite to form the Karnátí, called also the Ghargaṭa (or Ghogra), and this falls into the Ganges.

c. Again, between the ridge belonging to Dhawalagiri, and that of Goswámisthána, there are the rivers called collectively the Sapta-gandakí; and these, uniting into one stream which bears the name of the Gandaka, next join the Ganges.

d. Between the ridge of the Goswámisthána and that of Kanchangiri, there are the rivers called collectively the Sapta-Kauśika; and these uniting next join the Ganges in one stream which bears the name of the Kauśí. And so in the other valleys of like formation.

e. Now, on leaving the mountain valley, what kind of ground do these rivers meet with before reaching the Ganges? On this point we have to remark as follows:—

Aphorism XXXII.

These rivers cut their way through the range of sandstone hills that lies parallel to the Himálaya.

a. This range of sandstone hills is not more than from 300 to 600 feet above the ground on either side.

Aphorism XXXIII.

Above the sandstone range are the Dhúns, below is the Bhávar, and below that the Tará'í.

a. The mean breadth of the Himálaya is about ninety miles. Let this be divided into three portions, of thirty miles each, and it will present three climatic divisions, the lower, middle, and

upper. Let the lower region consist of the Tará'í, the Bhávar (or Sál forest), and the sandstone range with its Dhúns (or valleys),—i. e., let it occupy from the level of the plains to about 4000 feet above the sea:—the middle region will consist of the ground from there to about 10,000 feet above the sea; and the upper region, of the ground above that.

b. Now, we mentioned before (*Aph.* 27) that the tops of high mountains are cold; and it is evident that if there be snow on the top of a mountain, and the air be warm at the foot, the temperature must be gradually colder from the foot to the top. Now some animals love heat, and others love cold; and some plants love heat, and others love cold; and both animals and plants thrive best in those places where they find the temperature which they prefer. This is found to be the case all over the world; and how it is exemplified in the Himálaya we proceed to state:—

Aphorism XXXIV.

Plants and animals are different at different heights on the Himálaya, as is the case with other high mountains also.

a. Thus, as regards vegetation,—in the lower region there is the Sál (Shorea), the Síssú (Dalbergia), the Tund (Cedrela), the Palásа (Butea), the Banian (Ficus Indicus), the Peepul (Ficus religiosus), &c. In the middle region, instead of these, there are trees* that grow in such climates as that of England, and which will not thrive in warm climates. In the upper region there are pines, birches, and the congeners of such other plants† as

* Oaks, Alders, Cherries, Pears, &c., correct names for which are not hastily to be determined in the plains.

† Junipers, larches, &c.

love a degree of cold even greater than that of England.

b. As regards zoology,—in the lower region live such animals;—men* &c,—as love heat. In the middle region live such† as suffer in the heat of the lower region. In the upper region live such‡ as cannot thrive in the heat even of the middle region.

c. Then again, in the lower region there are elephants, rhinoceroses, tigers, and deer. In the middle region there are no elephants, rhinoceroses, or tigers, and only one kind of deer. In the upper region there are none of these elephants, deer &c., while in that region alone of the three are found the wild goat and the wild sheep. Then again, there are in the upper region no such crows as are seen in the lower one, and very few of these are met with even in the central one.

d. Thus, within the limits of the Himálaya, in consequence of the increasing coldness of the climate from the base upwards, there are to be found such climatic differences as are not usually to be met with except at wide intervals on the earth's surface.

e. We shall now mention the great divisions of the earth's surface as recognised by Europeans.

Aphorism XXXV.

The dry land is divided into four portions, called respectively Asia, Africa, Europe, and America.

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* The Koch, Bodo, Dhímal, &c.

† The Lepchas &c.

‡ The Bhotiyas.

a. The earth is in form, nearly a sphere, with a diameter of about eight thousand miles. More than two-thirds of the surface of the earth is covered by the ocean. Of the remaining dry land the great divisions are named as just mentioned.

Now, how are these four to be recognised?

Aphorism XXXVI.

Asia is the division in which India is situated, and Europe that in which is England:—Africa and Europe lie to the west of Asia, Europe being to the north of Africa:—America extends from north to south over great part of the hemisphere that is antipodal to India.

a. The forms and the relative situations of the various countries and seas on the globe are represented in maps, from which they may be learnt.

b. Some countries are warm, and some are cold. With regard to the principal reason of this we have to observe as follows:—

Aphorism XXXVII.

The climate of a country depends mainly upon its receiving the sun's rays perpendicularly or obliquely.

a. In countries near the equator, the sun's rays fall nearly perpendicularly upon the earth; and these countries are warm, as India. Countries placed nearer the pole receive the sun's rays obliquely, hence in smaller quantity, and are comparatively cold, as England.

b. We have already explained how rivers take their rise in mountains, as the Ganges &c., in the Himálaya mountains.

Now, in Africa the mountains are few; hence the rivers are few, and much of that region is consequently a desert.

c. In books on Geography, in addition to the relative positions of towns and countries, the religion, habits, forms of government, &c., of the inhabitants are detailed. For fear of prolixity we shall not here go into these topics.

d. Having now given some account of the surface-arrangement of the earth, we have next (—as intimated in APH. 24. BOOK II.—) to consider its constituent masses. Masses (—as hinted in *Aph.* 13. BOOK II.—) we regard as the products of Atoms, to which belong three important properties, as we proceed to indicate in the aphorism here following.

SECTION VI.

OF MATTER ~~AND MOTION~~ in Atoms.

Aphorism XXXVIII.

Now the enquiry has reference to Atoms, and their Attraction, Repulsion, and Inertia.

a. Atoms? Every material mass is divisible into very minute particles, indestructible by human power. For example, a piece of iron, or other metal, may be bruised, broken, cut, dissolved, or otherwised transformed, a thousand times, but can always be exhibited again as perfect as at first. Let the most minute resisting particles of which the mass is composed be called Atoms —i. e. what cannot be further cut or divided.

b. Their Attraction? It is found that the Atoms, whether separate or already joined into masses, tend towards all other

Atoms of masses,—as when the atoms of any mass, such as a stone, are held together (by some influence which we know only by its effects) with a certain force; or when a block of stone is similarly held down to the earth on which it lies; or when the sea (in the flow of the tide) rises towards the moon. Let the cause of these effects be called *Attraction.*

c. Repulsion? Atoms, under certain circumstances,—for example when Heat is diffused among them,—have their mutual attraction resisted, and they tend to separate,—as when ice heated melts into water, or when water heated expands into steam. Let the cause of these effects be called *Repulsion.*

d. Inertia? As a potter's wheel, when made to revolve, at first offers resistance to the force moving it, but gradually acquires speed proportioned to that force, and then resists being again stopped—in proportion to its speed, so all bodies and atoms appear to have, in regard to motion or rest, a *stubbornness*, tending to keep them in their existing state whether of motion or of rest. Let the cause of this be called *Inertia.*

e. Now we have to see how the enquiry into Atoms and their mutual Attraction, &c., is to throw light on the nature of the material universe; and we proceed in the first place to declare as follows.

Aphorism XXXIX.

The sensible universe is formed of Atoms.

a. As before mentioned, a piece of metal, after having been bruised and broken and dissolved and altered in a thousand ways, can be always recovered as perfect as at first. Although this is not the case with things that are organized,—as the leaves of trees or the feathers of birds,—for we cannot restore to an organized

structure the form that it had before,—yet, as we shall see when we come to the subject of Chemistry, even when these are burned, not a single Atom is really lost.

b. Now, with regard to the size of the Atoms.

Aphorism XL.

Atoms are extremely minute.

a. Among the proofs of this fact it may be mentioned that goldbeaters, by hammering, reduce gold to leaves so thin that 360,000 must be laid upon one another to produce the thickness of an inch. The thickness of even one of these leaves is, we know, much greater than that of an Atom, because gold can be spread out much thinner upon silver wire; and even then there is no proof that the thickness is no more than that of an Atom.

b. The followers of the Nyáya hold that the magnitude of an Atom is *smaller than any magnitude* (or *positively small*), so that the magnitude of an Atom is no element in the magnitude of a combination of two Atoms, because that which is produced from (the intensifying of) the *small* ought to be still smaller (—as in the multiplication of fractions by fractions,—or in the summation —as regards the positive result—of *minus* quantities in Algebra). We on the other hand (for the most part) hold, that, although exceedingly small in comparison with the masses formed of them, yet there is no reason why they should not possess a determinate bulk with reference to these,—so that the bulk of two* Atoms may be twice the bulk of one. Reasons for holding this opinion will be mentioned in the sequel.*

c. A European philosopher, of the name of Boscovich, put for-

* When treating of crystallization.

ward a theory that Atoms have no magnitude, and that they [differ from mathematical points only in as much as they] have primary force* [—or a repulsion which secures to each atom its own range]. Although this hypothesis is not devoid of plausibility, yet it does not serve so well to explain the varied phenomena of the material universe as the hypothesis followed in the present work:—we therefore proceed to lay down the following position.

Aphorism XLI.

Matter always occupies space.

a. A portion of matter, as a large mass of cotton, by being compressed, can be made to occupy a smaller space, but it cannot be so compressed as to occupy *no* space. In the same way all other bodies on no occasion altogether part with magnitude. This property of never ceasing to possess magnitude is called the *Impenetrability* of matter,—a term implying that no two or more bodies can occupy exactly the same place at the same time. The following are examples of this.

b. If a stone be dropped into a jar brimful of water, then water will flow out to make room for the stone.

c. A glass tube, left open at the bottom, while the finger closes the top, if pressed from air into water, is not filled with water, because the air contained in it resists; but if the air be allowed to escape by removing the finger from the top, then the tube becomes filled to the level of the water around it.

d. Invert in a vessel of water a smaller vessel full of air. Some water will enter; but the water cannot fill the smaller ves-

* See Preliminary Dissertations to the Enc. Brit. p. 606.

sel until, by turning its mouth upwards, we allow the air to escape. If the vessel of air be inverted over a floating lighted taper, this will continue to float under it, and to burn for some time in the contained air, however deep in the water it be carried. In like manner, in a large inverted vessel of air, suspended by a rope, men can be lowered to the bottom of the sea to recover sunken property. The vessel for this purpose, being usually shaped like a bell, is called a Diving-bell.

e. Now there must be some reason why Atoms do not remain separate, and therefore we conclude as follows.

Aphorism XLII.

Atoms attract each other.

a. In other words, there is a mutual *Attraction* among Atoms. Attraction exists also between the separate masses formed of atoms. Of this fact the following are instances.

b. Logs of wood floating in a pond, or ships in calm water, approach each other, and afterwards remain in contact.

c. As stones fall, and plummets hang, in India, towards the centre of the earth, so is it on the side of the globe opposite to India also. People there, therefore, like flies on the opposite side of a pane of glass, are standing with their feet towards us. Bhâskara Âchârya, in his *Goládhyáya*, illustrates this as follows.

"This (globe of the earth) is covered on every part with multitudes of mountains, groves, towns, and monuments, as is the ball of the Nauclea's globular flower with its multitudes of anthers."

d. "But then," some one might object, "men are not fastened into the ground as the anthers of the Nauclea flower are fastened into their globular receptacle so that they do not fall

away from it. How, then, do the men not fall off who are standing at the distance of a fourth part of the circumference from us, or in the opposite hemisphere?" To this Bhâskara Âchârya replies as follows.

"Each one, wherever he stands, regards the earth as being *under* him, and himself standing *upon* it:—therefore those that stand at the distance of a fourth part of the circumference from one another mutually regard one another as standing *horizontally*, and those that stand in the opposite hemisphere as having their heads downmost (and forming antipodes) like the man and his reflected image at the margin of a piece of water;—and thus those who are (as regards our own position) placed horizontally or head downmost, stand *there* just as we do *here*."

e. It is in consequence of all the parts tending to a common centre that the earth is spherical. In like manner when particles of mist coalesce into drops, these are spherical. They lose their spherical form, of course, when they reach the ground; but melted lead, allowed to run down from an elevated sieve, by cooling as it descends, retains the form of its liquid drops. It is in this way that the spherical small-shot used by sportsmen is made. Lead, when allowed to drop from a height, does not assume a spherical form if it is not in a fluid state. Hence we are led to conjecture that the earth, the moon, the sun, and the planets, all of which are round, must at some time have been to a certain degree fluid; and also that they are all subject to the same law of Mutual Attraction.

f. But it may be asked,—if all things on this globe tend to the centre, why is smoke seen to ascend? Smoke does not, of its own accord, ascend; but in reality the air near the earth, being heavier, sinks below it and forces it to rise, just as the water

in a jar causes a straw to rise which has been thrust to the bottom of it.

g. The cause which we call Attraction acts at all distances. The Moon, though 240,000 miles distant from the earth, by her attraction, raises the water of the ocean under her, and thus occasions what is called the *tide*. The sun, still further off, has a similar influence. When the sun and moon act in the same line of direction, (as they do twice in each month,) the tide is greater (—and is then called a spring-tide).

h. But, although Attraction acts at all distances, it does not at all distances act with equal force; and, in regard to this, we proceed to remark as follows.

Aphorism XLIII.

The Attraction is greater the nearer the bodies are to each other; as the light of a lamp is more intense nearer to the lamp than at a distance.

a. Place a wooden board of a foot square at a certain distance from a lamp, and it will just shadow a board of two feet square behind it at double the distance. Now a board with a side of two feet has four times as much surface as a board with a side of one foot, for it is not only twice as long, which would make it double, but twice as broad also, which makes it quadruple. Light, therefore, at double distance from its source, being spread over four times the surface, has only one fourth of the intensity. For a like reason, at thrice the distance, it has only a ninth part, and so on,—the light becoming less intense the more widely it is diffused, just as a bag of rupees, on being equally divided among a greater number of persons, allows a proportionally smaller amount to each. Now light, heat, attraction, sound, and indeed every influence from a central point, is found to de-

crease in the proportion here illustrated, viz., as the surface of squares, the one of which shadows the other, increases. Accordingly, what weighs 1000 pounds at the sea-shore, weighs five pounds less at the top of a mountain of a certain height. This is proved experimentally by using a spring-balance. The spring, drawn out to a greater length, indicates a greater weight at the level of the sea than on a lofty mountain. By calculating, according to the proportion of weight lost on a hill of a certain height, it is found that the weight, or tendency towards the earth, of 1000 pounds, must be diminished to five ounces at the distance of the Moon. This fact will be reverted to in the sequel.

b. In pouring water from a jar, it is seen that the water, in consequence of the attraction of the jar, does not readily leave it, but is inclined to run down the outside of the jar, which attracts it. It is in order to remove the water from the attraction of the vessel, that various vessels are furnished with spouts,—as is the case with the water-pots of Hindú ascetics. When a vessel has not a spout, you may pour from it without spilling, by leaning the lip of the vessel against a rod of glass, or the like, down which the liquid will readily run,—the attraction of the rod then counteracting that of the vessel.

c. The particles of water cohere among themselves in a degree which causes small needles, gently laid upon the surface, to float. The weight of the needles is not sufficient to overcome the cohesion of the water-surface. For the same reason many light insects can walk upon the surface of water without being wetted.

d. Between two plates of glass, or the like, standing near to each other with their lower edges in water, the water, attracted by them the more strongly in proportion to their closeness, rises

above the level of that on the outside. In the same way, water, ink, or oil, coming in contact with the edge of a book, is rapidly absorbed far inwards among the leaves; and the wick of a lamp lifts the oil, to supply the flame, from two or three inches below it.

e. It has been already remarked that when heat is diffused among the Atoms, they tend to separate. On this point we proceed to declare as follows.

Aphorism XLIV.

The Atoms are more or less close, according to the quantity of heat, producing repulsion, among them; and hence the forms of solid, liquid, and air.

a. But what is Heat? This we are not at present prepared to say. We shall consider Heat at present merely as a cause of Repulsion.

b. When a continued addition of heat is made to any body, it gradually increases the mutual distance of the constituent atoms, or dilates the body. A solid thus is at first enlarged and softened; then melted or fused, that is to say, reduced to the state of liquid, as the cohesive attraction is overcome; and lastly the atoms are repelled to still greater distances, so that the substance is converted into elastic fluid or air. Abstraction of heat from such air causes return of states in the reverse order.

c. Thus ice when heated becomes water, and water when further heated becomes steam. The steam when cooled becomes water, as before, and the water when cooled becomes ice. Ice, water, and steam, therefore, are three forms or states of the same substance. Other substances are similarly affected by heat; but as some require more heat to liquify them, and some less, it

is thus that we find the existing variety of solids, liquids, and airs.

d. We have now to consider some peculiarities of state which depend on certain modifications of Attraction and Repulsion.

Aphorism XLV.

Certain modifications of Attraction and Repulsion produce the peculiarities of state called Crystal, Porous, Dense, Hard, Elastic, Brittle, Malleable, Ductile, and Tenacious.

a. Crystallization? When various kinds of salts are dissolved in water, and the water is then allowed slowly to evaporate, each salt assumes a peculiar form and no other. From finding that certain substances thus invariably assume a regular form, we infer that, at the time when a mass is beginning to be formed, the Atoms do not attract one another equally all round, but that the Attraction acts between certain sides or portions, thus leading to the regular arrangement which we call the crystalline. The name is taken from rock-crystal, which is found in strikingly regular forms.

b. Porosity? Even among the particles of hard stones there are vacant spaces. Hence a kind of sandstone, suitably shaped, serves to filter water. Let the cause of its being fitted for this be called its Porosity.

c. Density? A cubic inch of mercury is nearly fourteen times heavier than a cubic inch of water. It is inferred that a greater quantity of Atoms exists in a given bulk of that which is the heavier. This is expressed by saying that the substance is more dense. When a body dilates or contracts by the addition or abstraction of heat, its entire weight does not change, because the quantity of its atoms does not change; but the weight of a

given bulk of it, as a cubic inch, changes, because the quantity of atoms in the cubic inch changes.

d. The comparative *weights of equal bulks* of different substances are called their specific gravities. Water is the standard employed for determining this, as will be shown in the sequel.

e. Hardness is that quality which may be measured by the power of one body to scratch another. The diamond is the hardest of known substances. It cuts or scratches every other body.

f. Elasticity is that which restores to its former position what had been forcibly altered as by bending.

g. Brittleness is the property of a body which, though hard, is easily broken. For example, glass scratches iron, so that it is harder than iron; yet it is very easily broken.

h. Malleability is the property, belonging to gold &c., of being reducible into thin leaves by hammering.

i. Ductility means the susceptibility, belonging to gold &c., of being drawn into wire.

j. Tenacity means that modification of the force of cohesion among the atoms of any mass, by which it resists being drawn asunder. A great weight can be supported by a thin iron wire; but only a comparatively small weight can be supported by a leaden wire of the same size. Tenacity, differing in degree in different substances, is most remarkably characteristic of iron.

k. As the bodies formed of atoms may be at rest or in motion, we have now to consider the phenomena of motion.

SECTION VII.

OF MOTION AND REST.

Aphorism XLVI.

Motion is the term applied to the phenomenon of the changing of place among bodies.

a. Motion is *straight,* in the apparent path of a falling body,—*curvilinear,* in the track of a body thrown obliquely,—*accelerated,* in a stone falling to the earth,—*retarded,* in the stone thrown upwards while rising to the point where it stops before descending.

b. Now, how is motion produced, and how does it cease?

Aphorism XLVII.

Force is required whether to give motion or to take it away.

a. It has been already mentioned that a potter's wheel first offers resistance to the force moving it, and then resists being stopped. So a person standing upright in a carriage falls backwards when the carriage suddenly moves forward; and the same person standing upright whilst the carriage is moving rapidly forward, falls forwards when the carriage suddenly stops. So too, when a boat crossing a river strikes against the bank, all the ignorant people who in their haste to get ashore have stood up, fall forward towards the bank.

b. But, whether is the state of rest or that of motion natural to bodies? To this we reply:—

Aphorism XLVIII.

Uniform straight motion is as naturally permanent as rest.

a. That is to say, a body can neither acquire motion, nor lose motion, nor bend its motion, without a cause.

b. When an iron ball is rolled on the ground, if the ground be not smooth, the motion is speedily destroyed. If the ground be smooth, then the motion, being less impeded, continues longer; yet it is gradually destroyed by obstacles which cannot here be entirely removed. It is only in the sky that we observe an entire absence of obstructions, and there the motions of the planets go on uninterruptedly.

c. An arrow discharged horizontally at a mark gradually bends downwards to the earth by which it is attracted; but, when the air is still, it does not tend to change its course either to the right hand or to the left:—were it not for this, no one could calculate upon taking a correct aim.

d. A stone from a whirling sling, the moment it is set at liberty, darts off as straightly as an arrow from the bow-string; and it is only because of the great difficulty, even after long practice, of determining the point of the circle from which it should depart, that it is so difficult to hit a mark with it.

e. From such facts it appears that a body moving in a circle is constrained by some force which is contrary to its Inertia. For example:—if a man is seen in the distance moving his hand, and a ball is seen whirling round it, then, though, from the distance or some other reason, we may see no string between his hand and the ball, yet we conclude with certainty that there is a string of some sort. In like manner, in the case of the circular motion of the moon and the planets, we infer that there is some force interfering with the straight motion which would else result from their Inertia, since a motion other than straight cannot be the result of any single force.

f. We have now, then, to consider the results of more than one force acting upon a body at once. It has been remarked that motion caused by a single force is always in a straight line. It is clear that an additional force applied in the same direction causes a body to move more rapidly in the same direction, as when a boat floating with the current of the Ganges is urged in the same direction by the wind also. When a force is directly opposed by an equal force, motion does not take place; so two bulls of equal strength, opposing their heads with equal force, both maintain their ground. Whichever of two opposing forces is the greater, motion takes place in the direction of that force, with a rapidity resulting from the difference of the two forces; as when a boat, with a fair wind, sails up against the current of the Ganges. These facts are quite obvious. The following is perhaps less so.

Aphorism XLIX.

If two forces act, upon a body, neither in the same direction nor in an exactly opposite direction, the body will move in an intermediate direction.

a. Thus a boat impelled by oars across a river, and at the same time acted upon by the current, moves neither straight across nor straight down the river, but slantingly. Therefore the ferryman, in order to bring his boat to the desired landing-place on the other side of a rapid river, calculating his own strength and that of the current, starts from such a point up the stream that the landing-place may lie rightly between the direction of the current and the direction that he labours in.

Aphorism L.

If two forces act upon a body, by one of which it is projected

in a straight line, whilst by the other it is continually directed towards a fixed point, the result is Circular Motion.

a. Thus when a sling, with a stone, is put in motion, the stone, which constantly seeks to move away, moves in a circle because it is restrained towards the hand. If, in the rapid motion, the string break, or if it be let go by the hand, then, since only one of the forces continues to act, the stone will fly off as if it had been thrown straight from the hand.

b. So also in an oil-mill, the ox, when driven, seeking to go forward, and prevented by the beam to which its neck is yoked, moves in a circle round the mill. If he were quit of the yoke, he would probably move off from his driver in a straight line,—his attempt to do this having conduced in the first instance to the circular motion which he is confined to.

Aphorism LI.

The force which pulls a body towards a centre is called the Centripetal Force. The force in virtue of which it tends to recede from a centre is called the Centrifugal Force. Together these are called Central Forces.

a. Phenomena exemplifying the centrifugal force are such as the following.

b. Bodies laid on a whirling horizontal wheel, such as that used by potters, are readily thrown off.

c. In a handmill the grain, carried round by the stone, travels outwards till it escapes as flour at the circumference.

d. When a water-pot, filled with water, is whirled rapidly round by means of a string fastened round its neck, the centri-

fugal force prevents the water from falling out even whilst the vessel is upside down.

e. A man or a horse, suddenly changing his direction in running (as when turning a corner at speed), instinctively leans inwards, or towards the new direction, to counteract the centrifugal force that would throw him away from it. A carriage, in rapidly rounding a corner, for want of such instinct, is apt to be overturned.

f. When a mass of very soft clay is placed in the middle of a potter's wheel rapidly revolving, the centrifugal force causes the clay to bulge out. Like this ball of soft clay, the Earth, revolving on its axis, has bulged out at the equator, so that the equatorial diameter exceeds the polar diameter by about twenty miles. In consequence of the existence of this additional mass of matter at the equator, the attraction between the Earth and the Sun and the Moon does not act exactly as it would do if the form of the Earth were a perfect sphere. Hence result the precession of the equinoxes and certain other irregularities to be noticed in the sequel.

g. Motion is said to be *uniform* when equal spaces are moved over in equal times. Motion is not necessarily uniform. In regard to this we have to remark as follows.

Aphorism LII.

Motion may be Retarded or Accelerated.

a. Retarded motion is produced by some force acting continuously on a body in a direction opposed to that which first put it in motion, and thus gradually diminishing its velocity. If you throw a stone vertically upwards, the attraction of the earth will

gradually diminish its velocity, till at length the upward motion ceases, and the stone begins to descend. The motion of the stone downwards is the converse of what it was upwards. Here we have Accelerated Motion. For, when the stone, by falling through a certain space, acquired a certain velocity, it would move, in consequence of its Inertia, through another equal space in an equal portion of time, without the application of any additional force. But the force of the Earth's attraction is still acting upon it, and thus the velocity is constantly accelerated.

b. When a boy lets a ball drop from his hand, he can catch it again in the first instant; but after a little delay his hand pursues it in vain.

c. When a *Bela* fruit falls from a lofty branch, the eye can follow it for a time, and mark the gradual acceleration of its descent; but soon, from the increasing rapidity of its fall, it is seen only as a shadowy line.

d. Any fluid falling from a reservoir forms a descending stream of which the bulk diminishes, from above downwards, in the same proportion as the velocity of the particles increases. For example, in pouring molasses, or thick syrup, from a considerable height, the bulky sluggish mass, which first escapes, is reduced, before it reaches the bottom, to a small thread; but the thread is moving proportionately faster, and fills the receiving vessel with surprising rapidity.

e. Some bodies are seen to fall to the earth more rapidly than others; but their doing so is owing to the interference of the air. A sheet of paper falls slowly; but if you roll it into a ball, it will fall rapidly. Gold is very heavy, but it appears to float in the air when beaten into thin leaf.

f. A piece of paper, cut to the size of a rupee, and placed

on the top of it, reaches the ground along with the rupee,—for the heavier body prevents the air from impeding the fall of the lighter one.

g. In a vessel from which the air has been removed by an air-pump, a rupee and a feather fall with equal rapidity.

h. A stone thrown straight forward is gradually drawn down towards the earth. If the motion caused by the earth's attraction were a uniform motion, like that caused by the current of a river, the stone, like the boat before referred to, would move in a slanting but straight line. As the downward motion, however, is a continually accelerated motion, the stone must continually change its direction, or, in other wards, it must move in a curve, as we see it do. The form of this curve is more distinctly seen when water is spirted from a syringe.

i. Both accelerated and retarded motion is exemplified in the Pendulum.

Aphorism LIII.

The name of Pendulum is applicable to any body so suspended that it may swing freely backwards and forwards.

a. A common pendulum consists of a ball suspended by a rod from a fixed point.

b. A stone suspended by a string will serve to exemplify several of the phenomena of the pendulum. One of the most important of these is the following.

Aphorism LIV.

The times of the vibrations of a Pendulum are very nearly equal, whether it be moving much or little.

a. 'Whether it be moving much or little'—i. e. whether the arc described by it be large or small. This may be shown by suspending a small weight from a peg by a thread of 39 inches in length. When the weight is drawn to one side and then set free, it will move backwards and forwards in equal spaces of time,—viz. in a second of time, whether it make a wide oscillation as when first set free, or a gradually smaller one.

b. It is in consequence of this property that the pendulum is employed to measure time. A common clock is merely a pendulum, with wheel-work attached to record the number of vibrations, and with a weight or spring having force enough to counteract the retarding effects of friction and the resistance of the air.

Aphorism LV.

The length of a pendulum influences the time of its vibration.

a. The shorter the string of the pendulum, the more rapid is its oscillation: and the longer the string the slower is the oscillation.

Aphorism LVI.

Action and Reaction are equal and opposite.

a. It is evident that if no action or movement takes place among bodies but in consequence of either Attraction or Repulsion, there must always be at least two bodies concerned, and each must be attracted or repelled just as much as the other, although one will have less velocity than the other, as it may be itself greater, or fixed to another mass.

b. Thus, if a man in one boat pull at a rope attached to another, the two boats will approach. The boat which he pulls will

come, and the boat in which he stands will *go* towards it. If they be of equal size and load, they will both move at the same rate; and if they be different, the smaller will move the faster, in whichever of them the man may be.

c. A cannon, when fired, recoils with not less momentum in it than the ball has; but, the momentum in the cannon, being diffused through a greater mass, the velocity is small, and easily checked.

d. When a body in motion strikes upon another body, it meets with resistance. The resistance of the body at rest, will be equal to the blow struck by the body in motion, and exactly opposed to it. The operation of this principle is most apparent in the case of elastic bodies. If a ball be rolled along a smooth floor so as to meet a wall perpendicularly, it will return on the same line. If the first motion be not in a direction perpendicular to the wall, the reflected motion will diverge exactly as much on the other side of the perpendicular. Thus, if, whilst standing in the left hand corner of a room, we throw a ball against the centre of the opposite wall, the ball, in returning, will move towards the right hand corner,—the angles on each side of the perpendicular being always equal. This equality of the angles, or law of reflection, which applies to Heat, &c., also, may be expressed as follows:—

Aphorism LVII.

The angle of reflection is equal to the angle of incidence.

a. Other examples of this will be noticed in the sequel.

b. Having thus shown how all the motions visible among bodies are the effects of nothing else than Attraction and Repulsion acting on the Inertia of Atoms, separate or conjoined, under diversified circumstances, we now proceed to explain, by

means of these principles, the peculiarities of rest and motion which depend on the *solid* form of bodies.*

SECTION VIII.

PHENOMENA OF SOLIDS.

c. '*Solid*' is the term applied to a mass in which the mutual attraction of the atoms is so strong that the mass may be moved about as one body, without the relative positions of the component parts being thereby disturbed. From this results the fact next stated.

Aphorism LVIII.

Force, moving part of a solid, must affect the whole or break off the part.

a. An earthenware vessel may be suspended by a portion of its lip (or by its handle), thus proving that the cohesion of the parts is stronger than the weight of the vessel; but if an attempt be made to lift the vessel quickly by such a part, the part may rise and leave the vessel behind,—because then the *inertia* is acting together with the weight to destroy the cohesion.

b. If any uniform rod be supported by its middle, like a weighing beam, the two ends will just balance each other. If equal weights be hung at the extremities of the arms, the equi-

* This is the division of science commonly called *Mechanics*. In regard to solid bodies, the phenomena of Rest are treated under the head of Statics (—properly Stereo-statics—), and those of Motion under that of Dynamics (properly Stereo-dynamics).

librium will still continue. The middle point in this case is called the *centre of gravity*; and that there is such a point in every mass we proceed to declare.

Aphorism LIX.

In every mass, or system of connected masses, there is a point around which all the parts balance each other, and this point is called the *centre of gravity* (or of inertia).

a. When this point is supported, the body does not fall. When this point is not supported, the body falls to that side on which the point is.

b. Thus the centre of gravity of a bar of wood or iron of uniform thickness is at the middle point. Support this point on your finger and the bar will remain supported. Move the point to either side and the bar will fall on that side.

c. A line drawn perpendicularly to the surface of the earth from the centre of gravity is called the line of direction. A body remains standing when the line of direction falls within the base on which the body is placed; otherwise it falls.

d. When people in a boat rise up, the centre of gravity of the whole, that is to say of the boat with its contents, is raised. A smaller inclination of the boat to one side will then make the line of direction fall beyond the base. When there is any risk of a boat's upsetting, therefore, the passengers ought to avoid starting up.

e. The centre of gravity of a sphere is the centre of the sphere. Wherever you place a spherical body of homogeneous material, on a horizontal plane, the centre of gravity being vertically over the point of contact, the sphere will rest. On the

other hand, if you place the sphere on a slope, the point of contact not being vertically under the centre of gravity, the body will roll down.

f. The centre of gravity of a body is not necessarily within the body itself. In a ring, of iron for instance, the centre of gravity is some where within the hollow in the midst. Suspend the ring from two several points, and tie two threads across it in the direction of the two lines of suspension. The ring will be balanced if you support the point of intersection of the threads.

g. On these properties of matter, and laws of motion, which we have described, depends the operation of numerous machines which have been contrived for the saving of human labour.

h. In looking at a potter's wheel revolving, the truth of the following proposition will become apparent.

Aphorism LX.

In a solid body moving about an axis, like a wheel or a weighing beam, the different parts have different velocities, according to their respective distances from the axis or centre.

a. It is clear that a piece of soft clay placed on the rim of the wheel, passes over, in one revolution, twice the space traversed by another piece placed midway between the centre and the circumference.

b. With reference to this the following is to be borne in mind.

Aphorism LXI.

Forces, with different speed, may be made to balance one another if they be connected by some solid medium in such a man-

ner that the speed of the smaller shall be the greater, just in proportion to the greater intensity of the other force.

a. Upon this important truth the whole of Mechanics may be said to hinge. On this depends the operation of the *simple machines,* or *mechanical powers,* as they have been called,—the lever &c., which enable man to adapt any species and speed of power which may be available, to almost any work which he has to accomplish.

b. The simplest of the mechanical powers is the *lever.* A lever is a rigid rod of uniform thickness, made, we may suppose, of wood or metal.

c. If the rod be placed upon a support which is called the *fulcrum,* at its centre, the two arms of the lever will balance each other.

d. If equal weights be hung at the extremities of the arms, the equilibrium will still continue. On this principle the common weighing balance is constructed.

e. If the lever be supported not at the middle, but at such a point that the one arm shall be twice as long as the other, then the centre of gravity will be removed to the side of the longer arm; and a weight suspended from the extremity of the longer arm will balance twice its weight suspended from the extremity of the shorter arm.

f. It is evident from this that if the arms of a weighing balance are unequal in length, an imposition in the weight of goods may be effected.

g. By moving the fulcrum still nearer to one end, a weight at the extremity of the longer arm may be made to balance three

times, four times, five times its weight at the other end, and so on indefinitely; and a small addition to the weight at the longer arm will enable it not merely to balance but to raise the larger weight. Thus a single person, by applying his strength at the longer end of a lever, is able to raise a weight which the combined force of several men could not move.

h. It is obvious that the extremity of the longer arm must be moved over a great space, in order to raise the extremity of the shorter arm through a small space; and thus, just as much as is gained in power is lost in time.

i. This applies not only to the lever but to all the other mechanical powers. It does not follow, however, that these are useless; for, since we cannot augment our strength, those instruments are highly useful which enable us to reduce the resistance or weight of any body to the level of our strength, at the expense of a corresponding portion of time.

j. Another great benefit resulting from the use of machinery, as already hinted, is this, that it enables us to take advantage of gratuitous forces, such as a current of wind, a stream of water, or the expansive power of steam. When such forces perform our task, we have only to superintend and regulate their operation.

k. So much for the peculiarities of solid bodies.

l. We have next to consider the peculiar properties of matter in the form of *liquid*.

SECTION IX.

HYDROSTATICS.

m. From their deficiency of cohesion, liquids cannot be maintained in heaps. The wind raises water into waves, but these are immediately afterwards destroyed by gravity. Thus:—

Aphorism LXII.

Liquids always tend to have their surface level.

a. As the particles of fluids gravitate independently, they press against each other in every direction, not only downwards but upwards, and sideways. The pressure of fluids upwards, though it seems in direct opposition to gravity, is a consequence of their pressure downwards.

b. When, for example, water is poured into a vessel with a spout, the water in the spout rises to a level with that in the pot. The particles of water at the bottom of the pot are pressed upon by the particles above them; they will yield to this pressure if there is any mode of making way for the superior particles, and as they cannot descend, they will change their direction and rise in the spout.

c. For the same reason water may be conveyed to every part of a town, if it be originally brought, by means of pipes, from a height superior to any to which it is to be conveyed. Many of the cities of Europe are supplied with water in this way.

d. When a tube with a very small bore is immersed in a vessel of water, the water rises higher in the tube than the surface of the water in the vessel, being attracted by the sides of the tube.

In this way [—see *Aph.* 43. *d.*—] the oil of a lamp rises amid the small tubes formed by the threads of the wick; and water rises in the very small tubes of trees and other vegetables.

e. We have already had occasion to mention [*Aph.* 45. *d.*] the *specific gravity* of bodies.

Aphorism LXIII.

Water is employed as the standard for determining the comparative weight, or specific gravity, of bodies.

a. When we say that a substance is light or heavy, we speak comparatively. Thus chalk is light when compared with iron, and heavy when compared with wood.

b. The comparative weight or specific gravity of a body is ascertained by weighing it first in air and afterwards in water.

c. A piece of gold will displace just as much water as is equal to its own bulk; so that a cubic inch of water must make way for a cubic inch of gold. The gold will weigh less in water than it did out of it, on account of the upward pressure of the particles of the water. Now supposing that a piece of gold weighed nineteen ounces out of the water, and lost one ounce by being weighed in water, the quantity of water which it displaces must weigh that one ounce: consequently gold must be nineteen times as heavy as water.

d. If the body under trial be of the same weight as the water in which it is immersed, it will be wholly supported by it, as was the water the place of which it occupies.

e. A body placed in water rests when it has displaced a quantity of water equal in weight to the weight of the body; but if the

bulk of the body be less than that of its weight of water, as in the case of a ball of clay, it will sink.

f. If the ball of clay be formed into a hollow jar, then it will displace a quantity of water more than equal to it in weight, and it will float.

g. A boat sinks the deeper in the water the more it is loaded, displacing just as much water as is equal to the whole weight; and thus iron boats can be made to float. Steamboats on the Ganges are made of iron.

h. In ascertaining the specific gravity of a body lighter than water, it is necessary to attach to it a body of known specific gravity sufficiently heavy to sink it.

i. Water, oil, milk, &c. are fluids which possess very little elasticity. Such fluids are called liquids. Other fluids have a remarkable degree of elasticity. Let us now consider, then, the mechanical properties of *elastic* fluids, or Airs.

SECTION X.

PNEUMATICS.

Aphorism LXIV.

The leading character in which air differs from such a fluid as water is its elasticity.

a. By the elasticity of air we mean its power of increasing or diminishing in bulk, accordingly as it is less or more compressed.

b. In consequence of its elasticity, air presses in all directions.

c. An important property, in respect of which air resembles water, is the following:—

Aphorism LXV.

The air possesses weight.

a. The following are proofs of this fact.

When we suck water through a straw, we do it by expanding the chest; this diminishes the compression of the air within our body, which then no longer counterbalances the pressure of the external air on the surface of the water by which the water is consequently forced up the straw.

c. The weight of a small quantity of air may be ascertained by exhausting the air from a bottle, by means of an air pump, and weighing the bottle thus emptied. Suppose that a bottle, six cubic inches in dimension, when the air is exhausted, weighs two ounces; if the air be then re-admitted and the bottle be re-weighed it will be found heavier by two grains; showing that six cubic inches of air weigh about two grains.

d. In order to ascertain the specific gravity of air, the same bottle may be filled with water, and the weight of six cubic inches of water will be found to be 1515 grains: so that the weight of the water to that of air is about 800 to 1.

e. For certain reasons it is supposed that the atmosphere is about 45 miles high. The weight of the upper portions causes the lower portions to be more dense. At the top of a high mountain the air is so thin that consideralbe difficulty is found in breathing there.

f. The height of a mountain may be estimated by means of an instrument called a *barometer*, or measurer of the weight of the air.

g. A barometer may be made thus. Fill with mercury a glass tube about three feet in length, and open only at one end. Then stopping the open end with the finger, immerse it vertically in a cup containing mercury. Part of the mercury which was in the tube now falls down into the cup, leaving a vacant space in the upper part of the tube, to which the air cannot gain access.—This space is therefore a perfect vacuum; and consequently the mercury in the tube is relieved from the pressure of the atmosphere, whilst that in the cup remains exposed to it. Therefore the pressure of the air on the mercury in the cup supports that in the tube, and the mercury will stand higher in the tube when and where the pressure of the atmosphere is greater.

h. The mercury in the barometer usually stands at the height of about 29½ inches.—When the *barometer* is carried up a hill, or to the top of a high tower, the atmospheric pressure being diminished, the mercury sinks. By means of numerous experiments it has been determined how many hundred or thousand feet of additional elevation correspond to a fall of an inch, or two inches, &c., of mercury in the tube, and thus it is that the instrument can be employed for measuring the height of mountains.

i. The mercury also sinks on the approach of a storm, so that it is of great value for giving warning of an approaching storm to ships at sea.

j. The atmospheric pressure which sustains in a tube a column of 29½ inches of mercury, ought to sustain a proportionately higher column of a fluid the specific gravity of which is less.—The specific gravity of mercury as compared with water is 13½. Multiplying this by 29½, the number of inches of mercury, we get somewhat more than 33 feet in height; and accordingly, on making the experiment, we find that the atmospheric

pressure sustains a column of water of above 33 feet in height.

k. The relative specific gravity of two fluids which, like mercury and water, are not disposed to mix with each other, may be determined by the following method. Place a glass tube, curved like the goad of an elephant, with the ends of the limbs uppermost, and pour into it so much of each of the two fluids that their point of meeting shall be the lowest point in the curvature of the tube. Then the heights to which the two fluids rise in the respective limbs will be in the inverse ratio of their relative specific gravity. For example, in such an arrangement, an inch of mercury in the one tube will be found to balance 13½ inches of water in the other; so that we conclude that mercury is 13½ times as heavy as water.

l. When such a curved tube as we have just described is reversed, it is called a syphon. Such is the instrument described by *Bháskara Achárya* in his *Siromani Mitákshara*, in the chapter on machines, where he says that if we place one end of such a curved tube, of copper or some other material, in a vessel full of water, the tube also being filled with water, and leave the other end open outside the vessel, all the water in the vessel will flow out through the tube.

m. In the same way if you use the hollow stalk of a lotus, the flower having been removed, a vessel of water may be emptied by it. Many ingenious machines are constructed on the principle of the syphon by conjurors and other artists.

n. The action of the syphon depends upon the weight of the atmosphere. The column of water in the external limb being longer than that in the limb immersed in the vessel, is heavier also. When it begins to fall, a vacuum would be formed in the upper part of the tube if the water in the shorter limb were not

immediately forced to ascend, by the pressure of the atmosphere on the surface of the water in the vessel.

o. The air is the most common vehicle of sound, but not the only one. On the subject of Sound we proceed to make some remarks.

SECTION XI.

ACOUSTICS.

Aphorism LXVI.

Sound is heard when any sudden shock or impulse is given to the air, or to any body which is in contact, directly or indirectly, with the ear.

a. Thus sound, as that of a bell, can be heard under water.

b. Solid bodies also convey sound, as may be thus proved. Fasten a string, by the middle, round a bar of iron, and raise the bar from the ground by the two ends of the string, one end being held against each ear closed. If the bar then be struck with another piece of iron, the sound will be conveyed to the ear by means of the strings in a much more perfect manner than if it had no other vehicle than the air.

c. When a sonorous body, such as a bell, is struck, it is put into a state of rapid vibration. This vibration it communicates to the air, and the air communicates it to our ear, where it produces the sensation of sound.

d. A bell rung in a vessel from which the air has been removed, gives no sound.

Aphorism LXVII.

The tremulous motion given to the air by the vibration of a sonorous body resembles in some measure the motion communicated to smooth water when a stone is thrown into it.

a. A stone thrown into smooth water, first produces a small circular wave round the spot where the stone falls; the wave spreads, and gradually communicates its motion to the adjoining waters, producing similar waves to a considerable extent.

b. It requires some time for the vibrations of the air to extend to any distant spot. A washerman at some distance is seen to strike a mass of wet clothes upon a stone some time before the sound of the blow is heard.

Aphorism LXVIII.

The velocity of sound in air is computed to be at the rate of 1142 feet in a second.

a. The nearly uniform velocity of sound enables us to estimate the distance of the object from which it proceeds. If we do not hear the thunder till half a minute after we see the lightning, we infer that the cloud is at the distance of six miles and a half.

Aphorism LXIX.

An echo is produced when the aerial vibrations meet an obstacle.

a. When the waves raised in a tank, by throwing a stone into it, meet the bank, they are reflected. So an echo is produced when the aerial vibrations meet with an obstacle having a hard and regular surface, such as a wall or a rock. The vibrations may thus be reflected back to the ear, and produce the same sound a second time; but the sound will then appear to proceed

from the object by which it is reflected; just as the image reflected by a mirror seems to the eye to be behind the mirror.

b. If the vibrations fall perpendicularly on the obstacle, they are reflected back in the same line; if obliquely, the sound returns obliquely on the other side of the perpendicular, the angle of reflection, in this case as in others, being equal to the angle of incidence.

c. In solids, liquids, and even airs, we have found that *weight* presents itself, as a result of Attraction. But in the great cause of *Repulsion*, viz. Heat, though we find some properties which it has in common with the bodies already treated of, we do not find any evidence of weight.

SECTION XII.

OF THE IMPONDERABLES, HEAT, ELECTRICITY, &c.

Aphorism LXX.

Heat cannot be exhibited apart, nor be proved to have weight or inertia.

a. An iron ball, by being heated, does not gain in weight.

Aphorism LXXI.

Heat diffuses itself among neighbouring bodies until all have the same temperature.

a. A heated iron ball, thrown into a vessel of water, becomes cooled, while the water becomes heated.

Aphorism LXXII.

The inferior degrees of heat are denoted by the term *cold.*

a. A man who has descended half way from the summit of a pass in the Himálaya, exclaims—"How warm the air is!"—while the man who has just arrived at the same point from the plains, rejoins, "On the contrary—how very cold!" The air feels hot or cold to each of these two because its heat is greater or less than that of the air that he has left. Thus we learn that Sensation is not a perfect criterion of Heat.

b. As these two men give opposite evidence, from their feelings, so a man's two hands may give opposite evidence in regard to the heat of a basin of water. Put your right hand into as cold water as you can procure, and your left hand, at the same time, into as hot water as it can suffer, and, after a little time, place both hands in a basin of tepid water. To the right hand it will feel warm, and to the left hand cold. This shows still more clearly that Sensation is not a trustworthy thermometer.

Aphorism LXXIII.

Heat expands bodies, and hence any substance so circumstanced as to allow the expansion to be accurately measured, constitutes a Thermometer.

a. The common thermometer, for measuring the degrees of heat, is a glass bulb filled with mercury or other fluid, and having a narrow tube rising from it, into which the fluid, on being expanded by heat, ascends, and so marks the degree of heat.

Aphorism LXXIV.

Heat travels through different substances with different degrees of rapidity.

a. A burning match can be held till the flame comes near the fingers; but a metallic wire, if one end be put into the flame of a lamp, speedily becomes too hot to be held.

Aphorism LXXV.

Heat travels also through space.

a. It is then called Radiant Heat.

b. Heat proceeds from a heated body, such as an iron ball, in straight lines, and in all directions. The law of the equality of the angles of incidence and reflection applies to these rays. If the rays proceeding in this way from the Sun are received in a concave metallic mirror, they will be all reflected into one point, where the heat will be sufficient to set various substances on fire. Two such mirrors facing each other may be so arranged at opposite ends of a room that food placed in front of one of them shall be cooked by a fire placed in front of the other.

c. When a glass tube is rubbed with a piece of silk, or a large stick of sealing wax with a piece of flannel, then, besides heat, another effect is observed (—to which the name of *electrical* is given). The tube first attracts, and then repels light substances, such as feathers, and small pieces of straw or paper.

d. If the finger be brought near a large tube thus excited, a spark leaves the tube, and a slight crackling noise is heard. The same phenomenon occurs, in dry weather, if the hand is drawn rapidly over the back of a cat.

e. The sublime phenomenon of thunder and lightning is of the same nature as that just described. Lightning has been drawn from the clouds by means of a kite, and the same experi-

ments have been performed with it, as with the electricity derived from the friction of glass and silk.

f. Electricity, like heat, always tends to an equilibrium. Hence a cloud which by any cause has become highly electrified, gives out its electricity with great noise and violence, when it comes within a certain distance of another less highly electrified cloud, or a tree, or a house.

g. When a body is highly electrified, its electricity can be drawn away without noise or violence by bringing a sharp-pointed piece of metal near it. Advantage is taken of this fact, to preserve houses from lightning in Calcutta and other places, by attaching to the house a metallic rod, one end of which is buried in the earth, and the other rises somewhat higher than the house.

h. When substances are undergoing chemical changes, electrical phenomena appear. Electricity thus developed is called Galvanism, from the name of its discoverer Galvani.

i. By means of Galvanism, information is conveyed in England in the course of a minute to places at the distance of hundreds of miles. If the requisite arrangements were completed, a message might be sent from Calcutta to Agra, Delhi, and Bombay, within the hour.

j. By means of Galvanism also we can, although standing at a great distance, instantaneously explode a barrel of gunpowder at the bottom of a river, and thus remove the wreck of a vessel which would otherwise obstruct the navigation of the river. This has been lately done in the Ganges on several occasions.

k. Another effect of electricity is its giving to a piece of soft iron the qualities of a magnet.

l. Light, also, is imponderable. The agency of Light in the phenomena of vision is the object of enquiry in the important department of science which we proceed next to treat of.

SECTION XIII.

OPTICS.

m. In this science, bodies are divided into *luminous, opaque,* and *transparent.* A luminous body is one that shines by its own light, as the sun, or a lamp. Polished metal, though it shines, is not luminous, for it would be dark if it did not receive light from a luminous body. It belongs to the class of opaque bodies which are neither luminous nor will allow the light to pass through them. Transparent bodies are those which allow the light to pass through them, such as glass and water. Transparent bodies are frequently called Mediums.

Aphorism LXXVI.

Light when emitted from a luminous body is projected in straight lines in every direction.

a. When the rays of light meet an opaque body, they are stopped short in their course. The interruption of the rays of light by the opaque body occasions darkness on the opposite side of it. If this darkness fall upon a wall or the like, it forms a shadow.

b. A shadow is not generally quite black, because it usually happens that light from another body reaches the space where the shadow is found, in which case the shadow is fainter. This happens if the opaque body be lighted by two lamps. If you extin-

guish one of them, the shadow will be both deeper and more distinct; yet it will not be perfectly dark, because it is still slightly illuminated by light reflected from the walls of the room, and other surrounding objects.

c. If the luminous body be larger than the opaque body, the shadow will gradually diminish in size till it terminate in a point. Thus the shadow of the moon, in an annular eclipse, terminates before it reaches the earth.

d. If the luminous body be smaller than the opaque body, the shadow will continually increase in size as it is more distant from the object that projects it. Thus the shadow of a man, thrown upon a wall by a lamp, may be twenty feet high or more.

Aphorism LXXVII.

Light moves with great velocity.

a. Light is about eight minutes and a half in its passage from the sun to the earth; therefore, when the rays reach us, the sun has quitted the spot he occupied on their departure; yet we see him in the direction of those rays, and consequently in a situation which he has abandoned about eight minutes and a half before.

b. The rate of the velocity of light was discovered in the following manner. We have already mentioned that the planet Jupiter is attended by four moons, which are very frequently eclipsed. When the earth is between Jupiter and the sun, then the earth is nearer to Jupiter, and when the sun is between the two, then the earth is further from Jupiter, by the distance of the diameter of the earth's orbit. Having ascertained exactly the time of the occurrence of the eclipses when Jupiter is near

the earth, astronomers calculated, in accordance therewith, the time of many future eclipses; but it was found that, when the planet was at its greatest distance, the eclipses did not become visible till about 16 minutes after the calculated time. It was inferred that light takes this amount of time to traverse the earth's orbit, and from this the velocity of light was determined as follows.—As the sun's distance from the earth is about ninety five millions of miles, Jupiter, when at his greatest distance, must be a hundred and ninety millions of miles further off than when he is at his least distance from the earth; and it follows that the velocity of light is nearly two hundred thousand miles per second.

Aphorism LXXVIII.

When rays of light encounter an opaque body, after being stopped short, they are mostly reflected, as an elastic ball when flung against a wall.

a. Here as in other cases, the angle of reflection is equal to the angle of incidence. Admit a ray of the sun into a dark chamber by a very small hole, and let the ray fall perpendicularly on a mirror. Only one ray will be seen, for the incident and reflected rays are both in the same line, though in opposite directions. Hold the mirror so that the ray shall fall obliquely upon it; and the reflected ray will go off at the same angular distance on the other side of the perpendicular.

b. It is by reflected rays alone that we see opaque objects. Luminous bodies send rays immediately to our eyes; but the rays which they send to other bodies are invisible to us, and are seen only when reflected by those bodies to our eyes. The path of the ray which we spoke of as falling on the mirror, and reflected from

it, was discernible only by means of the light reflected to the eye by small particles of dust floating in the air, on which the ray shone in its passage to and from the mirror.

Aphorism LXXIX.

When light passes from one into another transparent medium, it is refracted.

a. In consequence of this, when partly immersed in water, a staff appears shortened if it is placed vertically, and when it is placed obliquely the part immersed appears to be bent and broken off from the part above the water.

b. From the phenomena of refraction it would appear that when a ray of light passes from air into water, it is more strongly attracted by the water. If the ray fall perpendicularly on water, the attraction of the water acts in the same direction as the course of the ray. But if it fall obliquely, the water will attract it out of its course, and make it proceed in a direction more nearly vertical.

c. The converse is the case with a ray of light leaving a dense medium and entering a thinner one.

d. To show this,—place a silver coin at the bottom of a cup and set it so that the rim of the cup shall just intercept the rays of the sun or of a lamp and leave the coin in the shade. On filling the cup with water, the rays, being refracted downwards, will illuminate the coin.

e. Again, having emptied the cup replace the coin and move backwards till the rim of the cup shall hide the coin. Then let the cup be filled with water and the coin will become visible; for the rays reflected from the coin, and not intercepted by the

rim of the vessel, which previously passed above the eye, being now refracted downwards, meet the eye.

f. For the same reason the bottom of a clear stream or lake appears more elevated than it really is. Ignorant boys, unable to swim, have lost their lives by going to bathe where the water did not appear to them to be deep.

g. The rays coming from the sun or from a star when near the horizon, are refracted downwards when they enter the atmosphere. The situation of the heavenly body in such circumstances therefore appears to be higher than it really is, for the eye perceives an object in the direction which the ray coming from it takes at the instant when it meets the eye.

h. The rays coming from a body in the zenith are not refracted.—The amount of refraction is greatest at the horizon, from which it gradually diminishes towards the zenith. Hence at sunrise the lower limb of the sun is more affected than the upper, and when the air is rendered more refractive by damp, the disk assumes a form approaching to that of an egg.

i. In astronomical observations, allowance must be made for refraction. Tables of its amount, at all points between the horizon, where it is greatest, and the zenith, where it ceases, have been constructed, and are printed in Astronomical treatises.

j. In passing obliquely through a pane of glass, a ray of light suffers two refractions. On coming from the thinner air into the denser glass, the refraction is towards a perpendicular to the inner surface of the glass. On passing from the denser glass into the thinner air, the refraction is equally away from a perpendicular to the outer surface. The two refractions therefore, be-

ing in contrary directions, produce nearly the same effect as if no refraction had taken place.

k. But this is the case only when the two surfaces of the refracting medium are parallel to each other: if they are not, the two refractions may be made in the same direction. Thus when parallel rays fall on a piece of glass having a double convex surface, which is called a *lens*, that only is perpendicular to the surface which falls in the direction of the axis, the axis being the straight line passing through the centre of the lens and perpendicular to both surfaces. All the other rays meeting the surface obliquely are reflected toward that perpendicular. When the rays quit the glass at the inner surface, they are again refracted towards the axis, by diverging from the perpendicular at the point where they leave the glass. Thus the whole eventually converge to a point behind the glass, called the *focus*, at about the distance of the radius of the sphere of which the surface of the lens forms a portion.

l. The sun's rays may be collected to a focus by a lens which, when used for this purpose, is called a burning-glass; and a piece of paper held in the focus may be set on fire.

m. A convex lens serves also as a magnifying glass.

n. The reason of this is as follows. An object at a distance from the eye appears small, and what is near appears large. A small object is seen with most distinctness, by a well constituted eye, when at the distance of about five inches. If if be brought nearer, it appears larger, but less distinct. This can easily be put to the test by holding the book at the distance first mentioned, and then nearer to the eye.

o. The reason of the indistinctness in the latter case is as

follows. In the fore part of the eye there is a drop of pure liquid in the shape of a convex lens, the refractive power of which is such that rays diverging from a small object at the distance of about five inches are readily brought by it to a focus on the retina, where the concentration of rays produces distinct vision, but the refractive power is not sufficient to bring to a focus on the retina the rays diverging from a nearer object.

p. When people grow old, the fluid which forms the lens begins to diminish, and the convexity decreases, so that the letters of a book at the distance of five inches do not appear distinct to an old man. He sees more distinctly when he holds the book at arm's length.

q. This defect in the sight may be remedied in some measure by the use of convex spectacles, which cause the rays coming from any object to converge so far before reaching the eye that the lens of the eye can effect the rest.

r. By interposing a very refractive lens, a small object may be viewed distinctly when brought near the eye; and it then appears to be proportionately magnified. Such a glass is called a microscope.

s. A small convex lens may be obtained by piercing a small circular hole in a slip of metal, and introducing into it a drop of water, which will assume a spherical form on each side of the metal. Objects looked at through this will appear magnified.

t. If a lens be placed so as to fill up an aperture made in the window-shutter of a darkened room, and a sheet of paper be held at a proper distance behind it, then the objects outside, trees, houses, men walking, &c, will be represented on the paper. An arrangement analogous to this exists in the eye, as we shall show in the sequel.

u. The operation of a concave lens is the reverse of that of a convex lens. Objects seen through a concave lens are diminished.

v. In some young persons the lens of the eye is so highly convex that the rays come to a focus before they reach the retina.—From this focus the rays proceed divergently and consequently form a very confused image on the retina. Such persons see an object distinctly only when very near the eye.

w. Short sighted persons may enable themselves to see clearly at five inches distance by placing a concave lens before the eyes, in order to increase the divergence of the rays.

x. Short-sighted people may comfort themselves with the reflection that their eyes, by the flattening of the lens, may begin to improve, at a time of life when the sight of other people is beginning to fail.

y. There are other objects which though not really small, appear so to us, from their distance. In order to see these distinctly, we employ a Telescope.

z. The simplest form of Telescope consists of a convex lens fixed at the end of a tube, by which the rays from a distant object are made to converge; whilst the rays, before they come to a focus, are received on a concave lens which causes them to diverge so far as is necessary to give distinct vision. The object is thus seen magnified, and appears as if it were brought nearer.

Aphorism LXXX.

A beam of white light contains all the colours in nature.

a. Holding a clear glass bottle full of water higher than his head, or placing it on a support where a ray from the sun, coming into a dark room, may fall upon it, let the observer place

himself between the sun and the bottle; then the various hues which appear in the rainbow, will all be exhibited by the bottle.* Let the bottle be raised or lowered until one of the coloured rays appears; then let the bottle be gradually raised, or lowered, and the other coloured rays will be seen in succession. Now how can such a variety of colours issue from clear water? The answer is this, that all these coloured rays are contained in a ray of white light. We must give some explanation of this.

a. It has been already mentioned that opaque bodies are seen by means of the rays which they reflect. All objects do not reflect every ray. A body which reflects all the rays appears white. That which reflects none appears black.

c. Along with the rays of light, the heat that attends them is either reflected or absorbed. Hence, in the sunshine, black clothes, which absorb the rays, are warm, and white clothes, which reflect them, are cool. Black cloth, for the same reason, takes fire quickly when exposed to a burning glass, but not so white cloth.

d. A body which reflects the red rays, appears red, that which reflects the yellow rays appears yellow, and so in every case.

e. The refrangibility of the coloured rays which make up white light is not equal. The blue rays are more refrangible than the yellow, and these than the red. This can be best shown by means of a prism of glass.

f. Let this be placed so that the ray of light entering a dark chamber by a small hole shall fall upon it, then the ray which

* This was the experiment of Antonio de Dominis, bishop of Spalatro, A. D. 1611.

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first threw a white light on the opposite wall, will display the various colours of the rainbow. The refractions of the light, entering and quitting a prism, are both in the same direction, as in the case of a convex lens, and for the same reason; but, as its sides are flat, the rays are not brought to a focus.

g. If the coloured rays which have been separated by a prism are allowed to fall upon a convex lens, they will converge to a focus, where they will appear white as they did before refraction. Thus we can take a ray of white light to pieces, and put it together again.

h. The sun appears red through a fog, and also frequently at rising and setting, because the red rays, being less refrangible, reach our eyes, whilst the more refrangible rays do not.

i. The rainbow which exhibits a series of colours analogous to those of the prismatic spectrum, is formed by the refraction of the sun's rays in their passage through a shower of rain, every drop of which acts as a prism, in separating the coloured rays as they pass through it.

j. As all the drops which are placed at the same angle as regards the eye give the same colour, and the location of all the drops which are at similar angular distances from the eye must be in a circle, the form of the rainbow, of which we see only a portion, is necessarily circular.

k. "Inasmuch as the motion of bodies, the action of forces, and the propagation of influences of all sorts, take place in certain lines and over definite spaces, the properties of those lines and spaces are an important part of the laws to which those phenomena are themselves subject. Moreover, motions, forces or other influences, and times, are numerable quantities and the

properties of number are applicable to them as to all other things."* Intending in the next section, therefore, to speak of Number and Magnitude, we here close the present Book.

* Mill's Logic—vol. I. p. 394.

END OF THE SECOND BOOK.

भूमिका

सुनिपुणानां बुद्धिमतां विचारे परस्परविरोधः केवलं दुःखहेतुः। वादिप्रतिवाद्यभिमतार्थस्याभेदेऽपि यदि तयोर्भाषाभेदमात्रेण भेदावभासः तर्हि सोऽपि तथैव। अन्योन्यमततत्त्वपरीक्षणात्पूर्वं परस्परनिन्दादिकं निष्फलत्वादनुचितं। अपिच यच्च केवलं विवदमानयोर्द्वयोरपि भ्रान्तिमूलकविवाददूरीकरणार्थः प्रयत्नो महाफलत्वात्प्रशस्यस्तच्च भूखण्डद्वयनिवासियावद्यत्कीनां परस्परं विवाददूरीकरणार्थकप्रयत्नः प्रशंसायोग्य इति किं वक्तव्यम्। एतादृशप्रयत्नकारी पुरुषः सम्पूर्णफलस्याप्राप्तावपि न निन्द्यः। भारतवर्षीयार्यजनानां प्राचीनस्वमतग्रन्थपरिपालनं तत्प्रेमच तेषां महास्तुतिकारणम्। एवं प्रतिदिनंवर्द्धमानस्वमतग्रन्थाभ्यासजनितसततज्ञानदृष्ट्या सन्तुष्यन्तो यूरोपीयलोका अपि न निन्द्याः। यदि कश्चिद् युरोपीयजनो भारतवर्षीयार्योक्तं वास्तवमपि तदीयव्यवहारं तन्मततत्त्वंच यथार्थतोऽविज्ञाय निन्देत्तदनुचितमेव। एवं यदि भारतीयजनो युरोपीयमतमविज्ञाय निन्देत्तदपि तथैव। एवञ्च परस्परभ्रान्तिजनितमतविरोधप्रयुक्तदुःखस्य हेयतया तद्-

दूरीकरणायावश्यं कश्चिदुपायो ऽनुष्ठातव्यः । मिथोविरुद्धेच मतद्वये सत्यता न सम्भवति । अनुचितमतस्वीकारे सति सत्कालसम्भवोऽनीप्सितदुष्टफलसम्भवश्च । अतो विचारिणोर्द्वयोरेकविषये मतभेदे सदसन्निर्णयाय वादः समुचितः । परन्तु यावत्सम्यक्प्रकारेण मतभेदो नावधृतस्तावद्वादोऽपि न समीचीनः । प्रथमतो मतयोः यथासम्भवं साम्यं निर्णीय तदुत्तरं भेदनिर्णयः कर्तव्यः येन मतैक्ये विवादो न भवेत् ॥

तदेवं पूर्वोक्तहेतुना भारतीयानां युरोपीयानांच मतयोस्साम्यवैलक्षण्यनिर्णयेच्छायां जातायां यस्मिन् ग्रन्थविशेषे भारतीयमतं सम्यक् साकल्येन सृष्टीकृतं ग्रन्थान्वेषणं प्राप्तं । तच्च तर्कशास्त्रीयग्रन्थानवलम्ब्य मतैक्यवैलक्षण्ये परीक्षणीये यतस्तेषु निखिलदर्शनस्थविषयाः संक्षेपेण बहवश्चतच्छास्त्रीयविषया विस्तरेणोपलभ्यन्ते । भारतवर्षे बहूनां दर्शनानामुपलम्भेऽपि केवलं तर्कशास्त्रमाचेण सह युरोपीयमतस्य साम्यवैलक्षण्ये निरूपणीये नत्वन्यैरपि तर्कशास्त्रज्ञानस्य सकलशास्त्रज्ञानमूलत्वात् । यथा प्रयागगयाकाश्योर्मध्यकस्य नगरचक्रस्य परस्परविप्रकर्षं तद्वस्थितिदिग्भागांश्च यो वस्तुतो जानाति स चेदुज्जयिन्यादेर्नगरान्तरस्य तत्स्थितमध्ये एकेन केनचित्सह विप्रकर्षं दिशश्च जानीयादपराभ्या-

मपि ताभ्यां तद्विषये निर्णयवान् स्यात् सष्टत्वात् । तथा यदि सम्यक्परिचितसर्वदर्शनः पुरुषस्तर्कशास्त्रेण सह युरोपीयमतस्य सम्मतिविमती जानाति तर्हि अन्यैरपि वेदान्तादिशास्त्रैः सह तस्य साम्यवैलक्षण्यविषये गतसन्देहः स्यात् । तदेवं पूर्वोक्तविषयनिरूपणाय प्रारीप्सितस्य ग्रन्थस्याधिकारी स एव यो गौतमसूत्रप्रथमाध्यायार्थवेत्ताऽमत्सरश्च यतः प्रथमाध्याये गौतमेन सकलं न्यायमतं संक्षेपेण सूचितम् । मतयोर्वैलक्षण्ये परीक्षणीये प्रथमतो विस्तरेणैक्यनिर्णयो यथासम्भवं कर्तव्यः यतस्तत्रोपन्यस्तानां बहूनामुदाहरणानां वैलक्षण्यनिर्णये महानुपयोगो भविष्यति । अज्ञाततयुरोपीयमतसम्बन्धिविषयाणां अतिसंक्षेपरूपेण प्रकाशनार्थश्चैतद्ग्रन्थनिर्माणमहाप्रयत्नः । तथाऽपि यदि श्रोतृणां कस्मिंश्चिददृष्टाश्रुतपदार्थे सन्देहःस्यात् तर्हि तत्पदार्थनिरूपणनिपुणाद्गुरोपीयजनान्निर्णयः कर्तव्यो न तु ग्रन्थ एव ज्ञातव्यो ऽज्ञाततत्त्वे विषये बोधकापेक्षायाः सार्वत्रिकत्वात् । यः पुनर्विषयो यत्रादिद्वारकदर्शनादेव निर्णेतुं तत्त्वतः शक्यस्तस्य निर्णयस्तेनैव कर्तव्यो न तु तद्ग्रन्थवाक्यमात्रेण । यदि चाधीतात्मज्ञानशास्त्रः प्रेक्षावानेतद्ग्रन्थद्वितीयप्रकरणे उपन्यस्तानां भौतिकपदार्थानां निरूपणं न रुच्या प्राधान्येन द्रक्ष्यति तर्हि अनुमानीयदृष्टान्तमिच्छार्थमेव

तत्प्रकरणं जानातु । यदि पुनरात्मतत्त्वज्ञो विविधवस्त्ररज्जुप्रभृतीन् तत्तद्व्यापारांश्च अन्ये निरूपितानतितुच्छान्मन्येत तर्हि यथैव पूर्वेषां ज्योतिःशास्त्राचार्याणां न्यायाचार्याणां वा अन्येषु दृष्टान् तत्तद्यन्त्रचादीन् दण्डचक्रचीवरकुलालकपालप्रभृतींश्च जिज्ञासुजनबोधनार्थान् दृष्टान्तान्मन्यते तथैवैतानपि स्वीकरोतु तत्तत्पदार्थस्वरूपपरिचये सति तदीयबहुविधापूर्वधर्मज्ञानरूपस्य महाफलस्य सम्भवात् ॥

॥ श्री परमेश्वरो जयति ॥

परमेश्वरकृपया चिरमर्थं बुध्वाच्चपादसूचार्णां रचये वृत्तिमपूर्वामिङ्गडीयाच्चपादतर्कैक्यां ॥

बहुलप्रयत्नरचिताबच्चर्थाख्याच्चराप्यसन्दिग्धा बालग्रहैनस्य कृतिर्भूयादेषा मुदे विदुषां ॥

इह खल्वात्मादेः प्रमेयस्य तत्त्वज्ञानं परमपुरुषार्थोपकारीति सर्वे भारतवर्षीयास्तदन्यवर्षीयाश्चानुमन्यंते शास्त्रकृतः। अतः परमपुरुषार्थार्थिभिरवश्यं तदात्मादितत्त्वज्ञानप्राप्तौ यतितव्यं। तत्प्राप्तौच करणमपेक्ष्यत इति तत्करणादीनि विचारयिष्यन् प्रमाणरूपकरणपुरसरं एतद्ग्रन्थविषयानुद्दिशति प्रमाणेत्यादिना ।

प्रमाणप्रमेयसंशयप्रयोजनदृष्टांतसिद्धांतवा-
यवतर्कनिर्णयवादजल्पवितंडाहेत्वाभासच्छ-
लजातिनिग्रहस्थानानां तत्वं विचार्यते त-
त्वज्ञानाय तस्य परमपुरुषार्थोपकारित्वात्
॥ १ ॥

अत्र चानुबंधाः विषयप्रयोजनसम्बन्धाधिकारिणः । विषयः प्रमाणादयः । प्रयोजनञ्चैतन्न्याध्ययनप्राप्यं तत्वज्ञानं पुरुषार्थप्रयोजकत्वात् । प्रतिपाद्यप्रतिपादक-भावस्सम्बन्धः । उपदिष्टार्थशुश्रूषुरत्सरोऽधिकारीति ॥

तत्वज्ञानं च क्रमेण परमपुरुषार्थोपकारीति क्रमप्र-तिपादनाय सूत्रं ॥

दुःखजन्मकुप्रवृत्त्यनुचितरागादिमिथ्या-
ज्ञानानामुत्तरोत्तरापायमंतरा न परमः
पुरुषार्थः ॥ २ ॥

अस्यायमर्थः । अस्तिच तावत् मिथ्याज्ञानमनेकप्रकारकं । तस्माच्चानुचितरागादिकं भवति । आदिपदेनासूयादयो गृह्यंते । तस्माच्च जन्मकुप्रवृत्तिर्भवति । जन्म जीवितं ननु पुनर्जीवितं लक्षयति । तस्मिन् जीवितकाले अनुचितरागादिजन्या कुप्रवृत्तिः कुत्सिताचरणं तस्माच्च दुःखमुत्पद्यते । अथ तत्वज्ञानं मिथ्याज्ञाननाशकं । मिथ्याज्ञानापायमंतरा न तज्जन्यरागादिरपैति । तदपायमंतरा न तज्जन्या कुप्रवृत्तिरपैति । तदपायमंतरा न दुःखापायः । दुःखापायमंतरा न परमः पुरुषार्थः संभवतीति । इदंतु बोध्यम् । अनुचितरागादिकं केवलमिथ्याज्ञानजन्यमस्तीति न । किन्तु मिथ्याज्ञानजन्यं यद्यदनुचितरागादिकं तस्य तदापायमन्तरा अपायो न भवति इति दिक् ॥

अथ यथोद्देशं लक्षणस्यापेक्षितत्वात् तत्वज्ञानकरणभूतं प्रथमोद्दिष्टं प्रमाणं लक्षयति विभजतेच ॥

॥ प्रत्यक्षानुमाने प्रमाणे ॥ ३ ॥

अत्रच प्रमाकरणत्वं प्रमाणत्वं। प्रमाच यथार्थज्ञानं। लक्षितस्य विभागः प्रत्यक्षानुमाने इति। अथ शब्दोपमानयोरपि प्रमाणत्वात् कथमुक्तं प्रमाणद्वयमेवेति चेदुच्यते। न तावच्छब्दोपमाने अतिरिक्तप्रमाणे तयोर्लिंगविधया अनुमितिकरणत्वात् प्रमाणद्वयमेवेति सिद्धम॥

अथ विभक्ते यथाक्रमं लक्षयितुमारभते॥

इंद्रियार्थसन्निकर्षोत्पन्नयथार्थज्ञानकरणं प्रत्यक्षं॥ ४॥

इंद्रियस्यार्थेन सन्निकर्षात् उत्पद्यते यत् यथार्थं ज्ञानं तत्करणं चक्षुरादि प्रत्यक्षप्रमाणमित्यर्थः॥

अनुमानं लक्षयति विभजतेच॥

अथ तत्पूर्वकं त्रिविधमनुमानं पूर्ववच्छेषवत्सामान्यतो दृष्टंच॥ ५॥

अथेति। तत्पूर्वकं प्रत्यक्षपूर्वकं त्रिप्रकारकमनुमानमित्यर्थः। तस्य त्रैविध्यं दर्शयितुमाह पूर्ववदित्यादि।

यच्च कारणेन कार्यमनुमीयते तत् पूर्ववत्। यथा मेघोन्नत्या भविष्यति वृष्टिरिति। यच्च पुनः कार्येण कारणमनुमीयते तत् शेषवत्। यथा पूर्वोदकविपरीतमुदकं नद्याः पूर्णत्वं शीघ्रत्वंच स्रोतसो दृष्ट्वा ऽनुमीयते भूता वृष्टिरिति। यच्चैकच्च पुष्पितात्रदर्शनादन्यत्रापि पुष्पिता आम्रा इति तत सामान्यतो दृष्टमिति॥

अथ शिष्यबोधनार्थमेवोपमानशब्दौ दर्शयिष्यन्नादावुपमानं लक्षयति॥

प्रसिद्धसाधर्म्यात्साध्यसाधनमुपमानं॥ ६॥

प्रसिद्धस्य पूर्वंज्ञातस्य साधर्म्यात् सादृश्यज्ञानात् साध्यस्य साधनं सिद्धिर्यतस्तदुपमानमित्यर्थः। यथा अयं गोसदृश इति॥

शब्दं लक्षयति॥

आप्तोपदेशः शब्दः॥ ७॥

स्पष्टम्। विभजते॥

स द्विविधो दृष्टादृष्टार्थत्वात् ॥ ८ ॥

स शब्दो द्विप्रकारक इत्यर्थः । यस्येह दृश्यते ऽर्थस्स दृष्टार्थः । यथा गंगादिशब्दः । यस्य चामुत्र प्रतीयते ऽर्थः सो ऽदृष्टार्थः । यथा स्वर्गादिशब्द इति ॥

॥ समाप्तं प्रमाणप्रकरणम् ॥

अथानेन करणेन किं वेद्यमित्याकांक्षायां प्रमेयप्रकरणमारभमाणः प्रमेयं विभजते लक्षयतिच ॥

आत्मशरीरेन्द्रियार्थबुद्धिमनः-
कुप्रवृत्तिरागादिसांसारिकजीवनफ
लदुःखपरमपुरुषार्थाः प्रमेयं ॥ ९ ॥

अत्रच आत्माच शरीरंच इंद्रियाणिच अर्थाश्च बुद्धिश्च मनश्च कुप्रवृत्तिश्च रागादिच सांसारिकजीवनंच फलंच दुःखंच परमपुरुषार्थश्चेति विग्रहः ॥

तत्र प्रथमोद्दिष्टमात्मानं लक्षयति ॥

इच्छाद्वेषप्रयत्नसुखदुःखज्ञानान्या-
त्मनो लिंगं ॥ १० ॥

लिंगं लक्षणमित्यर्थः ॥
क्रमप्राप्तं शरीरं लक्षयति ॥

चेष्टेंद्रियार्थाश्रयश्शरीरम् ॥ ११ ॥

चेष्टाच प्रयत्नजन्यो व्यापारविशेषः । चक्षुरादीनी-
न्द्रियाणि । अर्थस्सुखदुःखे । एतेषामाश्रयः शरीरमि-
त्यर्थः । अत्र चेष्टाश्रयत्वादि प्रत्येकं लक्षणं ॥
क्रमप्राप्तमिंद्रियं विभजते लक्षयतिच ॥

घ्राणरसनचक्षुस्त्वक्श्रोत्राणींद्रियाणि
भूतजन्यद्रव्यगुणग्राहकाणि ॥ १२ ॥

भूतानि वक्ष्यमाणानि । तज्जन्यगुणग्राहकाणीति स्व-
स्वविषयग्रहणलक्षणानींद्रियाणीत्यर्थः ॥

भूतान्येव कानीत्याकांक्षायामाह ॥

सुवर्णप्रभृतीनि भूतानि ॥ १३ ॥

सुवर्णमभिश्रितं तदादीन्यभिश्रितानि भूतानीत्यर्थः ।
पृथिव्यादीनां भूतत्वमस्ति नवेत्यग्रे विवेचयिष्यते ॥
क्रमप्राप्तमर्थं विभजते लक्षयतिच ॥

गंधरसरूपस्पर्शशब्दा भूतजन्य
द्रव्यगुणास्तदर्थाः ॥ १४ ॥

तदर्था इति तेषामिंद्रियाणामर्थाः । विषया इत्यर्थः ॥
बुद्धिं लक्षयति ॥

बुद्धिरुपलब्धिर्ज्ञानमित्यनर्थान्तरम् ॥ १५ ॥

अनर्थान्तरं समानार्थकमित्यर्थः ॥
मनो लक्षयति ॥

युगपज्ज्ञानानुत्पत्तिर्मनसो लिंगं ॥ १६ ॥

युगपदेककाले । एकात्मनीति पूरणीयं । ज्ञानानाम-
नुत्पत्तिर्यतस्स एव धर्मो मनसो लिंगं लक्षणमित्यर्थः ॥

प्रवृत्तिं लक्षयति विभजतेच ॥

प्रवृत्तिर्बुद्धिशरीरारम्भः ॥ १७ ॥

उचितानुचितभेदेनापि प्रवृत्तेर्द्वैविध्यम् ॥

रागादि लक्षयति ॥

प्रवर्त्तनालक्षणं रागादि ॥ १८ ॥

प्रवर्त्तना प्रवृत्तिहेतुत्वं । तदेव लक्षणं यस्य तादृशं रागादि । आदिपदार्थो वक्ष्यमाण इति ॥

सांसारिकजीवनं लक्षयति ॥

ऐहिकदेहात्मसंयोगस्सांसारिकजीवनं ॥ १९ ॥

स्पष्टं ॥ फलं लक्षयति ॥

प्रवृत्तिजनितार्थः फलं ॥ २० ॥

प्रवृत्तेरुचितानुचितात्मिकायाः जनितोऽर्थस्सुखदुः-

ख

खोपभोगस्तत्कालमित्यर्थः ॥

दुःखं लक्षयति ॥

बाधनालक्षणं दुःखं ॥ २१ ॥

बाधना पीडा तदेव लक्षणं यस्य तादृशमित्यर्थाः ॥

सकारणं परमपुरुषार्थं दर्शयति ॥

परमेश्वरप्रसादात्पर-
मः पुरुषार्थः ॥ २२ ॥

स्पष्टं ॥

॥ समाप्तं प्रमेयप्रकरणं ॥

अथ उद्देशलक्षणमाचेणात्मादिप्रमेयानामङ्गीकारासंभवात्तदर्थमुपपत्तिर्निरूपणीया । साच संशय-पूर्विकेति क्रमप्राप्तं संशयं लक्षयति ॥

सामान्यप्रत्यक्षाद्विशेषाप्रत्यक्षा-
द्विशेषस्मृतेश्च संशयः ॥ २३ ॥

सामान्यप्रत्यक्षात् सामान्यधर्मवद्धर्मिग्रहणात्। विशेषाप्रत्यक्षात् विशेषाग्रहणात्। विशेषस्मृतेः विशेषधर्मस्य स्थाणुत्वपुरुषत्वाद्देर्ग्रहणात्संशयो भवति ॥

अथ प्रयोजनाभावे संशयनिवृत्तये यत्नो न क्रियते। अतः क्रमप्राप्तं प्रयोजनं लक्षयति ॥

यमर्थमधिकृत्य प्रवर्त्तते तत्प्रयोजनं ॥ २४ ॥

अधिकृत्य उद्दिश्य। तथाच प्रवृत्तिहेत्विच्छाविषयः प्रयोजनमित्यर्थः ॥

अथ दृष्टांताभावे सिद्धांताभावेवा उपपत्त्यसंभवात् क्रमप्राप्तं दृष्टांतं लक्षयति ॥

लौकिकपरीक्षकाणां यस्मिन्नर्थे
बुद्धिसाम्यं स दृष्टांतः ॥ २५ ॥

अत्र लौकिकाः प्रतिपाद्याः। परीक्षकाः प्रतिपादकाः। तेषां यस्मिन्नर्थे बुद्धिसाम्यं ज्ञानाविरोधो भवति स दृष्टांत इत्यर्थः। तथाच वादिप्रतिवादिनिश्चयविषयो

दृष्टांत इत्याशयः । यथा वह्निसाधने महानसं वह्न्यभावसाधने महाह्रद इति ॥

॥ समाप्तं न्यायपूर्वाङ्गप्रकरणं ॥

क्रमप्राप्तं सिद्धांतं लक्षयति ॥

तंत्राधिकरणाभ्युपगमसंस्थितिस्सिद्धांतः ॥ २६ ॥

तंत्रं शास्त्रं । तदेवाधिकरणं यस्य तादृशो यो अभ्युपगमस्तस्य संस्थितिरिदमित्थमिति व्यवस्था । तथाच शास्त्रितार्थनिश्चयस्सिद्धांत इत्यर्थः ॥

विभजते ॥

सर्वतंत्रप्रतितंत्राधिकरणाभ्युपगमसंस्थितीनामर्थान्तरभावात् ॥ २७ ॥

सर्वतंत्रादिसंस्थितीनामर्थान्तरभावाद्भेदादित्यर्थः तथाच चतुर्विधस्सिद्धांत इति फलितं ॥

सर्वतंत्रसिद्धांतं लक्षयति ॥

सर्वतंत्राविरुद्धस्तंत्रे ऽधिकृ-
तस्सर्वतंत्रसिद्धांतः ॥ २८ ॥

सर्वतंत्राविरुद्धस्सर्वशास्त्राविरुद्धस्तंत्रे प्रकृतशास्त्रे अ-
धिकृतस्सर्वतंत्रसिद्धांतः । यथा गंधादयो घ्राणादींद्रि-
यग्राह्या इति ॥

प्रतितंत्रसिद्धांतं लक्षयति ॥

समानतंत्रसिद्धः परतंत्रासि-
द्धःप्रतितंत्रसिद्धांतः ॥ २९ ॥

समान इतिएकंतंत्रसिद्धः परतंत्रासिद्धस्तथाच वादि-
प्रतिवाद्येकतरमाचाभ्युपगतः प्रतितंत्रसिद्धांत इत्यर्थः ।
यथेह्लुडीयानां भूभ्रमणमिति ॥

अधिकरणसिद्धांतं लक्षयति ॥

यत्सिद्धावन्यप्रकरणसिद्धिस्सो
ऽधिकरणसिद्धांतः ॥ ३० ॥

यस्यार्थस्य सिद्धौ सत्यां अन्यस्यार्थान्तरस्य प्रक-

रणात् सिद्धिर्भवति सोऽधिकरणसिद्धान्तः । यथा प्रपञ्चस्य जन्यत्वे साध्यमाने परमेश्वरस्य सर्वज्ञत्वं ॥

अभ्युपगमसिद्धांतं लक्षयति ॥

अपरीक्षिताभ्युपगमात् तद्विशेषपरीक्षणमभ्युपगमसिद्धांतः ॥ ३१ ॥

अपरीक्षितस्य साक्षादसूचितस्य । अभ्युपगमादभ्युपगमज्ञापकं यत्तद्विशेषपरीक्षणं भवति तस्मादविशेषपरीक्षणात् ज्ञायते असूचितमभ्युपगतं सूचकृतेति सोऽयमभ्युपगमसिद्धांत इत्यर्थः । यथा गौतमेनाभ्युपगतं मनस इंद्रियत्वमिति ॥

॥ समाप्तं न्यायाश्रयसिद्धांतप्रकरणं ॥

क्रमप्राप्तानवयवान् लक्षयितुं विभजते ॥

प्रतिज्ञाहेतूदाहरणोपनयनिगमनान्यवयवाः ॥ ३२ ॥

अत्र प्रतिज्ञादयः पंचन्यायावयवा इत्यर्थः । पंचावय-

वकथनं परार्थानुमानाभिप्रायकं ॥

प्रतिज्ञां लक्षयति ॥

साध्यनिर्देशः प्रतिज्ञा ॥ ३३ ॥

साधनीयस्यार्थस्य यो निर्देशस्सप्रतिज्ञावयव इत्यर्थः ॥

यथा भूर्गोलाकृतिरिति ॥

क्रमप्राप्तं हेतुं लक्षयति विभजतेच सूत्राभ्याम् ॥

उदाहरणसाधर्म्यात्साध्यसाधनं
हेतुः तथा वैधर्म्यात् ॥ ३४ ॥

अत्र साध्यसाधनं हेतुरिति सामान्यलक्षणं । तस्य द्वैविध्यमाह उदाहरणसाधर्म्यात् तथा वैधर्म्यादिति । साधर्म्यमन्वयः । तादृशव्याप्तिरित्यर्थः । तथा चान्वयव्याप्तिकहेतुबोधको हेत्ववयव इत्यर्थः । यथा उक्तसाध्ये नियतगोलच्छायावत्त्वात् । यत् नियतगोलच्छायकं तत् गोलं दृष्टं यथा कंदुकमिति । वैधर्म्यं व्यतिरेकः । तथाच व्यतिरेकव्याप्तिहेतुबोधको हेत्ववयव इत्यर्थः । यथा उक्त-

साध्ये नियतगोलच्छायावत्त्वात् । यद्गोलं न भवति न तत् नियतगोलच्छायकं यथा स्तंभ इति ॥

क्रमप्राप्तमुदाहरणं लक्षयति ॥

साध्यसाधर्म्यात्तद्धर्मभावी दृष्टांत उदाहरणं ॥ ३५ ॥

साध्यसाधर्म्यात् साध्यसहचरितधर्मात् । तद्धर्मभावीति तं साध्यरूपं धर्मं भावयतीति । तथाच साधनवत्ता-प्रयुक्तसाध्यवत्तानुभावकोऽवयव इत्यर्थः । यथा यद्यत् नियतगोलच्छायकं तद्गोलाकृतिकं यथा कंदुकमिति ॥

व्यतिरेक्युदाहरणं लक्षयति ॥

तद्विपर्ययाद्वा विपरीतं व्यतिरेक्युदाहरणं ॥ ३६ ॥

तद्विपर्ययादिति साध्यसाधनव्यतिरेकव्याप्तिप्रदर्शनात् । तथाच साध्यसाधनयोर्व्यतिरेकव्याप्त्युपदर्शकोदाहरणं व्यतिरेक्युदाहरणमित्यर्थः । यद्गोलं न भवति न तत् नियतगोलच्छायकं यथा स्तंभ इति वाकारः प्रयोगसूचकः ॥

क्रमप्राप्तमुपनयं लक्षयति ॥

उदाहरणापेक्षस्तथेत्युपसंहारो न त-
थेति वा साध्यस्योपनयः ॥ ३७ ॥

साध्यस्य पक्षस्य उदाहरणापेक्षः उदाहरणानुसारी य उपसंहारः उपन्यासः स उपनयावयव इत्यर्थः । स द्विविधोऽन्वयिव्यतिरेकिभेदात् । तथेति साध्यस्योपसंहारो ऽन्वय्युपनयः । यथा तथाचेयं भूः । न तथेति साध्यस्योपसंहरो व्यतिरेक्युपनय इति ॥

निगमनं लक्षयति ॥

हेत्वपदेशात्प्रतिज्ञायाः पुनर्वचनं निगमनं ॥ ३८ ॥

हेतोरर्थात्तिविशिष्टपक्षधर्मस्य अपदेशः कथनं तत्पूर्वकं प्रतिज्ञायाः पुनर्वचनं निगमनावयव इत्यर्थः । यथा तस्माज्ज्वालाकारा भूरिति ॥

॥ समाप्तं न्यायस्वरूपप्रकरणं ॥

अथ प्रतिवादिनो निर्णयप्रतिबन्धकहेतौ व्यभिचारशंकानिरासार्थं तर्कस्यावश्यकत्वात् निर्णयात्पूर्वं क्रमप्राप्तं तर्कं लक्षयति ॥

अविज्ञाततत्त्वेऽर्थे कारणोपपत्तितस्तत्त्वज्ञानार्थमूहस्तर्कः ॥ ३९ ॥

अत्र तर्क इति लक्ष्यनिर्देशः। ऊह इति लक्षणं। ऊहश्च तर्कयामीत्यनुभवसिद्धो मानसो धर्मः । तर्कः किं स्वत एव निर्णायकः परंपरयावेत्यत आह कारणेति। कारणस्य व्याप्तिज्ञानादेरुपपादनद्वारेत्यर्थः। तथाच नियतगोलच्छाया यदि गोलव्यभिचारिणी स्यात् तर्हि गोलजन्या न स्यादित्यनेन व्यभिचारशंकानिरासे निराबाधं व्याप्तिज्ञाने न भुवो गोलत्वानुमितिरिति ॥

क्रमप्राप्तं निर्णयं लक्षयति ॥

विमृश्य पक्षप्रतिपक्षाभ्यामर्थावधा-

रणं निर्णयः ॥ ४० ॥

विमृश्य संदिह्य पक्षप्रतिपक्षाभ्यां स्वपक्षस्थापनपरपक्षदूषणाभ्यां अर्थावधारणं निर्णय इत्यर्थः ॥

॥ समाप्तं न्यायोत्तराङ्गप्रकरणं ॥

॥ इति प्रथमस्याध्यायस्याद्यमाह्निकं ॥

अथ तर्कानंतरं साधुस्तत्वजिज्ञासुर्वादमंतरा कदाचिन्निर्णयं न प्राप्नोतीति क्रमप्राप्तं वादं लक्षयति ॥

प्रमाणतर्कसाधनोपालंभः सिद्धांताविरुद्धः पंचावयवोपपन्नपक्षप्रतिपक्षपरिग्रहो वादः ॥ ४१ ॥

अथ वाद इति लक्ष्यनिर्देशः। एकाधिकरणस्थौ विरुद्धौ धर्मौ पक्षप्रतिपक्षौ। तयोः परिग्रहस्तत्साधकोक्तिप्रत्युक्तिरूपवचनसंदर्भ इत्यर्थः। प्रमाणतर्कसाधनोपालंभः प्रमाणैस्तर्केणच साधनं स्थापनं तथा उपालंभः निषेधश्च यस्मिन् तादृश इत्यर्थः। सिद्धांताविरुद्धस्सिद्धांता-

नुकूलः । पंचावयवोपपन्नः पंचावयवयुक्त इत्यर्थः ॥

जिगीषयाहि धूर्त्तास्तत्वजिज्ञासाच्छलेन जल्पं कुर्वन्तीति क्रमप्राप्तं जल्पं लक्षयति ॥

यथोक्तोपपन्नः छलजातिनिग्रहस्थानसाधनोपलंभो जल्पः ॥ ४२ ॥

यथोक्तोपपन्न इति अनेनप्रमाणतर्कसाधनोपालंभः पक्षप्रतिपक्षपरिग्रह इति लभ्यते । छलजातिनिग्रहस्थानैस्साधनोपालंभो स्थापनानिषेधो यस्मिन् क्रियेत इति । तथाचोभयपक्षस्थापनावती विजिगीषुकथा जल्प इत्याशयः ॥

धूर्ता अपि जल्पासमर्था वितण्डां कुर्वंतीति क्रमप्राप्तां वितंडां लक्षयति ॥

स प्रतिपक्षस्थापनाहीनो वितण्डा ॥ ४३ ॥

स जल्पः । प्रतिपक्षो द्वितीयः पक्षः । तथाच प्रतिपक्षस्थापनाहीना विजिगीषुकथा वितण्डेत्यर्थः ॥

॥ समाप्तं कथाप्रकरणं ॥

अथ जल्पकादयस्त्वमतनिर्णये हेतुमप्राप्य हेत्वाभासान् प्रयुंक्ते । तथा भ्रमात्साधवोऽपीति क्रमप्राप्तान हेत्वाभासान् लक्षयति विभजतेच ॥

सव्यभिचारविरुद्धप्रकरणसमसाध्यसमातीतकाला हेत्वाभासाः ॥ ४४ ॥

सव्यभिचारश्च विरुद्धश्च प्रकरणसमश्च साध्यसमश्च अतीतकालश्चेति विग्रहः । हेतुवदाभासन्त इति हेत्वाभासा दुष्टहेतव इत्यर्थः ॥

सव्यभिचारं लक्षयति ॥

अनैकान्तिकस्सव्यभिचारः ॥ ४५ ॥

एकस्य साध्यस्य तद्भावस्यवा योऽन्तस्सहचारस्तथाचैकमाचव्याप्तिग्राहकस्सहचारस्त्वेकांतिकस्तदन्योऽनैकांतिकः । यथा पर्वतो धूमवान् वह्नेरिति । सच

साधारणादिभेदात्त्रिविध इति ॥

क्रमप्राप्तं विरुद्धं लक्षयति ॥

सिद्धान्तमभ्युपेत्य तद्विरोधी विरुद्धः ॥ ४६ ॥

सिद्धांतं साध्यमभ्युपेत्य उद्दिश्य प्रयुक्तः तद्विरोधी साध्याभावव्याप्त इति फलितार्थः । यथा वह्निमान ह्रदत्वादिति ॥

क्रमप्राप्तं प्रकरणसमं लक्षयति ॥

यस्मात्प्रकरणचिन्ता स निर्णयार्थ-
मपदिष्टः प्रकरणसमः ॥ ४७ ॥

स हेतुस्वसाध्यस्य परसाध्याभावस्य वा निर्णयार्थमपदिष्टः प्रयुक्तः प्रकरणसम उच्यते । सक इत्याकांक्षायामाह यस्मादिति । प्रकरणं साध्यतदभाववंतौ । तथाच निर्णयार्थं प्रयुक्तो हेतुर्यच्च निर्णयं जनयितुमशक्तः किं-

त धर्मिणस्साध्यवत्वं तद्भाववत्वंवेति चिन्तां प्रवर्त्तयति स प्रकरणसम इत्युच्यते। यथा शब्दो नित्यश्शब्दत्वात्। शब्दो ऽनित्यः कृतकत्वादिति ॥

क्रमप्राप्तं साधसमं लक्षयति ॥

साध्याविशिष्टश्च साध्यत्वात्साध्यसमः ॥ ४८ ॥

साध्येनाविशिष्टः कुत इत्यत आह साध्यत्वादिति। साधनीयत्वादित्यर्थः। यथाहि साध्यं साधनीयं तथा हेतुरपिचेत् साध्यसम इत्युच्यते। अत एवचासिद्ध इति व्यवह्रीयते। अयंचाश्रयासिद्धादिभेदेन त्रिविध इति ॥

क्रमप्राप्तमतीतकालं लक्षयति ॥

कालात्ययापदिष्टः कालातीतः ॥ ४९ ॥

कालस्य साधनकालस्यात्यये अभावे अपदिष्टः अयुक्तो हेतुः। एतेन साध्याभावप्रमालक्षणार्थ इति सूचितं। साध्याभावनिर्णये साधनासंभवात् अयमेव बा-

धितसाध्यक इति गीयते। यथा वह्निरनुष्णः कृतक-त्वादिति ॥

॥ समाप्तं हेत्वाभासप्रकरणं ॥

हेत्वाभासान् साधुरपि भ्रमादेव प्रयुंक्ते इत्युक्तं। अथ धूर्त्तमात्रप्रयुक्तं क्रमप्राप्तं छलं लक्षयति ॥

वचनविघातो ऽर्थविकल्पोपपत्त्याच्छलं ॥ ५० ॥

अर्थस्य वाद्यभिमतस्य यो विकल्पो विरूद्धः कल्पो अर्थांतरकल्पनेति यावत् तदुपपत्या युक्तिविशेषेण यो वचनस्य वाद्युक्तस्य विघातो दूषणं छलमित्यर्थः। वक्तृतात्पर्याविषयार्थकल्पनेन दूषणाभिधानमिति फलितार्थः ॥

छलं विभजते ॥

तच्त्रिविधं वाक्छलं सामान्यच्छलमुपचारच्छलंच ॥ ५१ ॥

वाक्छलादिभेदात् त्रिविधं छलमित्यर्थः ॥
वाक्छलं लक्षयति ॥

अविशेषाभिहितेऽर्थे वक्तुरभिप्रायाद-
र्थान्तरकल्पना वाक्छलं ॥ ५२ ॥

यत्र शब्दस्यार्थद्वयं तत्राविशेषेण एकतरानिश्चये न अभिहितेऽर्थे कथिते सति वक्तुरभिप्रायादर्थान्तरस्य वाद्यनभिमतस्य कल्पनया दूषणाभिधानं वाक्छलमित्यर्थः । यथा गौर्विषाणीत्युक्ते कुतो गजस्य शृंगमिति ॥

सामान्यछलं लक्षयति ॥

सम्भवतोऽर्थस्यातिसामान्ययोगादसम्भू-
तार्थकल्पना सामान्यछलं ॥ ५३ ॥

जातिसम्बन्धात् संभवदर्थाभिप्रायेणोक्तस्य अति सामान्ययोगादसंभवदर्थकत्वकल्पनया दूषणाभिधानं सामान्यछलं । यथा ब्राह्मणोऽयं विद्याचरणसंपन्न

इत्युक्ते कथमस्य विद्याचरणसंपन्नत्वं बाल्ये व्यभिचारादिति ॥

उपचारछलं लक्षयति ॥

धर्मविकल्पनिर्देशेऽर्थसद्भावप्रतिषेध उपचारछलं ॥ ५४ ॥

धर्मविकल्पोऽन्यच्च दृष्टस्यान्यच्च प्रयोगः तस्य निर्देशे अर्थसद्भावप्रतिषेध उपचारछलं। यथा मञ्चाः क्रोशंतीत्युक्ते मंचस्थ पुरुषाः क्रोशंति नतु मंचा इति ॥

प्रसंगात् छलं पूर्वपक्षयति ॥

वाक्छलमेवोपचारछलं तदविशेषात् ॥ ५५ ॥

शब्दस्यार्थान्तरकल्पनया तयोरविशेषात् वाक्छलमेवोपचारछलं। तथाच द्विविधमेव छलमित्यर्थः ॥

समाधत्ते ॥

न तदर्थान्तरभावात् ॥ ५६ ॥

वाक्छलमेवोपचारछलं न भवति तयोरर्थांतर भावाद्भिन्नत्वादित्यर्थः ॥

विपक्षे बाधकमाह ॥

अविशेषेवा किंचित्साधर्म्यादेकच्छलप्रसंगः ॥ ५७ ॥

यत्किंचिद्धर्मादविशेषे यत्किंचित्साधर्म्यात् छलत्वादिरूपाच्छलैक्यं स्यात् नतु त्वदभिमतं द्वित्वमपीति ॥

॥ समाप्तं छलप्रकरणम् ॥

क्रमप्राप्तां जातिं लक्षयति ॥

साधर्म्यवैधर्म्याभ्यां प्रत्यवस्थानं जातिः ॥ ५८ ॥

साधर्म्यवैधर्म्याभ्यां प्रत्यवस्थानं दूषणाभिधानं जातिरित्यर्थः । तथाच छलभिन्नदूषणासमर्थमुत्तरं स्वव्याघातकमुत्तरं वा जातिरिति सूचितं ॥

क्रमप्राप्तं निग्रहस्थानं लक्षयति ॥

विप्रतिपत्तिरप्रतिपत्तिश्च निग्रहस्थानं ॥ ५९ ॥

विपरीता प्रतिपत्तिर्विप्रतिपत्तिः परस्थापितार्थप्रतिषेधः प्रतिषेधानुद्धरणं वा अप्रतिपत्तिः उभयंच निग्रहस्थानं पराजयप्राप्तिः ॥

जातिनिग्रहस्थानयोर्विभागो नास्तीति भ्रमवारणायाह ॥

तद्विकल्पाज्जातिनिग्रहस्थानबहुत्वं ॥ ६० ॥

तयोर्विप्रतिपत्त्यप्रतिपत्त्योर्विकल्पाद्भेदाज्जातिनिग्रहस्थानानां बहुत्वं। इत्थंच तयोर्बहुत्वेऽपि अन्यविषयकशिष्यजिज्ञासायाः प्रतिबंधान्नेदानीं तद्विभागः क्रियत इति भावः ॥

इति श्रीमज्जेमस् बालशैनविरचितायां न्यायसूचकौमुद्यां प्रथमोऽध्यायस्य प्रथमाह्निकः ॥

अथ प्रथमाध्याये प्रत्यक्षकरणानामिन्द्रियाणां तदर्थानाञ्च उद्देशः कृतः । इदानीं विशेषेण तल्लक्षणानि दर्शयितव्यानि । तत्र प्रथमोद्दिष्टं घ्राणेन्द्रियं लक्षयति ॥

॥ गंधग्राहकमिन्द्रियं घ्राणं नासावर्त्ति ॥ १ ॥

गंधग्राहकमिन्द्रियं घ्राणेन्द्रियमित्यर्थः । नन् कथं तस्य गंधग्राहकत्वं इति चेदुच्यते । गंधवत् पदार्थांशाः श्वासद्वारा नासां प्रविश्य यदा घ्राणेंद्रियेण सह संयुज्यन्ते तदैव प्रतिबन्धकाभावे गन्धज्ञानमुत्पद्यते । इति तस्य गन्धग्राहकत्वं ॥ यादृशशक्तिसत्वेनैव पदार्थांशानां घ्राणेन्द्रियेण सह संयोगे सति गंधज्ञानमुत्पद्यते तादृशशक्तिमत्पदार्थो गंधवान् बोध्यः । शक्तिनिरूपणंचाग्रेस्फुटीभविष्यति ॥ क्रमप्राप्तं रसनेन्द्रियं लक्षयति ॥

॥ रसग्राहकमिन्द्रियं रसनं जिह्वावर्त्ति ॥ २ ॥

रसग्राहकमिंद्रियं रसनेंद्रियमित्यर्थः । कथं तस्य रसग्राहकत्वं इति चेदुच्यते । मुखप्रविष्टा रसवत्पदार्था मुखजलसंयोगेन द्रवीभावं प्राप्ता यदा रसनेंद्रियसंयुक्ता भवन्ति तदैव प्रतिबन्धकाभावे रसज्ञानमुत्पद्यते इति तस्य रसग्राहकत्वं । याट्टशशक्तिसत्वेनैव रसनेंद्रियसंयुक्तपदार्थगतरसप्रत्यक्षं भवति स एव पदार्थो रसवानित्यभिधीयते ॥ क्रमप्राप्तं चक्षुरिन्द्रियं दर्शयति ॥

॥ रूपग्राहकमिन्द्रियं चक्षुर्नेत्रवर्त्ति ॥ ३ ॥

रूपग्राहकमिन्द्रियं चक्षुरिंद्रियमित्यर्थः । कथं तस्य रूपग्राहकत्वं इति चेदुच्यते । स्वतःप्रकाशात् परतःप्रकाशाद्वा पदार्थादागतं यत्तेजो यदा नेत्रं प्रविशति तदा तत्तेजःसम्बद्धस्यरूपस्य चाक्षुषज्ञानमुत्पद्यते । तेजः स्वरूपं तेजोरूपयोः सम्बन्धः नेत्रघटकावयवव्यवस्था-

चाग्रे विचारणीया ॥
क्रमप्राप्तं त्वगिन्द्रियं दर्शयति ॥

स्पर्शग्राहकमिन्द्रियं त्वक् सर्वशरीरवर्त्ति अंगुल्यग्रेषु तस्योत्कर्षः संख्यापरिमाणादीनां तत एव विशेषावगमात् ॥ ४ ॥

स्पर्शग्राहकमिन्द्रियं त्वगिंद्रियमित्यर्थः ॥ क्रमप्राप्तं श्रवणेंद्रियं लक्षयति ॥

कर्णवर्त्तीन्द्रियं श्रोत्रं ॥ ५ ॥

अथैतेनेंद्रियेण किं ज्ञायते। उच्यते। श्रवणानुकूल कर्णवर्त्तित्वचः स्पंदनात् शब्दो ज्ञायते। शब्दस्य स्वरूपं कर्णघटकावयवव्यवस्थाचाग्रे विचारणीया ॥

इतीन्द्रियनिरूपणं समाप्तं ॥ अथेदानीमिंद्रियाणामर्था दर्शनीयाः। तत्र प्रथमोद्दिष्टं गंधं दर्शयति ॥

याट्शशक्त्या द्रव्यांशानां घ्राणेंद्रियेण सह संयोगे सति गंधज्ञानमुत्पद्यते सेव शक्तिर्गन्ध इत्यभिधीयते ॥ ६ ॥

यद्यद्गन्धवत् तत् सर्वं पृथिवीति नियमे मानाभावात् फलाभावाच्चैतन्नियमं त्यक्त्वायस्मिन् यस्मिन द्रवद्रव्ये अद्रवद्रव्ये वा गंध उपलभ्यते तत् गंधाश्रय इति व्यवह्रीयते। एतद्विषये किंचिदग्रे विचारयिष्यते ॥

क्रमप्राप्तं रसं निरूपयति ॥

याट्शशक्त्या द्रव्यांशानां रसनेन्द्रियसंयोगे सति रसज्ञानमुत्पद्यते सा शक्तीरस इत्युच्यते ॥ ७ ॥

अस्मन्मते स्वच्छजलस्यापि न रसवत्त्वं किन्तु मुखसम्बन्धिजलेन रसवद्द्रव्ये द्रवीभूते सति इन्द्रियसन्निकर्षद्वारा रसप्रत्यक्षं भवतीति रसप्रत्यक्षे जलस्योपयोगित्वमिति ॥

क्रमप्राप्तं रूपं निरूपयति ॥

चक्षुषा तेजःसंयोगे सति यादृशशक्त्या
रूपप्रत्यक्षं भवति सा शक्तीरूपं इ-
त्यभिधीयते ॥ ८ ॥

तेजसस्तत्तद्द्रव्यसंयोगजन्या अवस्थाविशेषा अग्रे विचारणीयाः ॥

अथ चक्षुरिन्द्रियं स्वत एव पदार्थदूरत्वज्ञापकं न वेत्याकांक्षायां सूत्रम् ॥

यत्पदार्थस्य न स्पष्टरूपादिज्ञानं तस्य
दूरत्वमदृश्यमस्पष्टरूपादिज्ञानात्तस्य
तदनुमेयम् ॥ ९ ॥

तस्य पदार्थस्य दूरत्वमदृश्यं चाक्षुषप्रत्यक्षाविषय इत्यर्थः । नन्वेवं सति तत् कथं ज्ञायत इत्याकांक्षायामाह अनुमेयमिति । अनुमित्यात्मकज्ञानविषय इत्यर्थः । तंत्र हेतुमाह अस्पष्टरूपादिज्ञानादिति । तथाहि । यत्समीपस्थं तत् प्रायः स्पष्टं दृश्यते यच्च न

तथा तदस्पष्टं दृश्यते । यथा । अतिसूक्ष्मगवाक्षद्वारा महावृक्षस्याप्यस्पष्टत्वेन ज्ञानमभवति तादृशास्पष्टत्वज्ञानात् तस्य दूरत्वमनुमेयमेवेति । अत एव यद्यपि सूर्यस्य दूरत्वं पञ्चचत्वारिंशन्नियुतक्रोशपरिमितमस्ति तथापि अतिस्पष्टदर्शनात् तस्य तन्नानुमीयते किन्तु कुम्भकारचक्रात्तस्याल्पतरपरिमाणं चक्षुषा गृह्यत इति ॥

अस्पष्टत्वादित्यत्रादिपदात् पूर्वज्ञातस्य महत्परिमाणविशिष्टपदार्थस्य अल्पत्वेन ज्ञानं तज्ज्ञानकारणाज्ञानञ्च । यथा । मिहिकायां सत्यां सायङ्कालिकतमसि वा समीपवर्त्ती काकादिः दूरवर्त्ती हस्तीव गृह्यते अल्पत्वज्ञानकारणमिहिरान्धकारादेरननुसन्धानादिति ॥

क्रमप्राप्तं स्पर्शं निरूपयति ॥

द्रव्ये त्वगिन्द्रियसंयोगे सति यादृशजात्या स्पार्शनप्रत्यक्षमुत्पद्यते सा शक्तिः स्पर्शः ॥ १० ॥

क्रमप्राप्तं शब्दं निरूपयति ॥

यादृशशक्त्या द्रव्यविशेषस्य स्पन्दनेन
श्रावणप्रत्यक्षानुकूलत्वक्स्पन्दनमुत्प-
द्यते सा शक्तिः शब्द इत्युच्यते ॥ ११ ॥

यथाच शब्दोत्पत्तिस्थानविशेषद्रव्यस्पन्दनस्य वाय्वा-दिद्वारा कर्णवर्त्तित्वक्स्पन्दनोत्पादकस्य शब्दोत्पादकत्वं तथाग्रे वक्ष्यते ॥

अथ श्रोत्रेन्द्रियं स्वत एव पदार्थदूरत्वज्ञापकं नवे-त्याकांक्षायां सूत्रम् ॥

शब्दोत्पादकपदार्थस्य दूरत्वं न श्रूयते
किन्तु तत्तच्छब्दस्य महत्वलघुत्वानु-
सारेण तत्तच्छब्दकारणदूरत्वसमीप-
त्वज्ञानानुसारेण चानुमीयते ॥ १२ ॥

शब्दस्येति । दूरत्वं न श्रूयते न श्रवणेन्द्रियजन्य-प्रत्यक्षविषयीक्रियत इत्यर्थः । अथ कथं तर्हि त-

ज्ञानमित्यत आह किन्त्विति । अनुमीयत इति । अनुमानप्रमाणविषयीक्रियत इत्यर्थः । तथाहि । कश्चिन्निरिनदीधारापतनदेशसमीपस्थस्तत्पतनशब्दं परिमाणं निश्चित्य ततः क्रमशोऽपसृत्य अपसरणदेशदूरत्वानुसारेण पूर्वशब्दमल्पपरिमाणकं शृणोति । तदनु तत्सौच्म्येण प्रायशो यथार्थमेव धारापतनदेशदूरत्वमनुमातुं शक्नोति । एवमेव यदा शब्दकारणमतिदूरवर्त्तीति ज्ञायते तदा ज्ञातपरिमाणापेक्षया महत्परिमाणं शब्दस्य स्यादित्यप्यनुमातुं शक्नोति । अत एव यः कश्चित्यच्चक्रोशपरिमितदेशादागतः शब्दः सन्निहितनलिकाशब्दादप्यल्पतरोऽपि शतघ्नीशब्द एवार्यमिति तत्कारणदूरत्वज्ञैरनुमीयते । यदिच ध्वनिकारणस्य दूरत्वं सामीप्यं वा न जानीयात्तर्हि दूरवर्त्तिमेघस्य अथवा समीपवर्त्तिरथस्यायं ध्वनिरिति शंका भवेत् तस्मात् दूरत्वमनुमेयमेवेति सिद्धम् ॥

अथैवं निरूपिता ये रूपादयो गुणास्तद्वन्ति द्रव्याणि प्रत्येकं कतिविधानि इत्याकांक्षायां सूचम् ॥

वहिरिन्द्रियग्राह्यगुणवद्द्रव्याणि कार्य्यकारणगत-

महत्त्वाणुत्वधर्मभेदात् प्रत्येकं द्विविधानि ॥ १३ ॥

वहिरिन्द्रियग्राह्या ये रूपादयो गुणास्तद्वन्ति द्रव्याणि द्विविधानीत्यर्थः । कथं तेषां द्वैविधं इत्यत उक्तं कार्येति । कार्यद्रव्यगतं यन्महत्त्वं तदाश्रयो महद्द्रव्यं । एवं तत्कारणद्रव्यगतं यदणुत्वं तदाश्रयो ऽणुद्रव्यमेव इति द्वैविधं सिद्धं । परमाणुनिरूपणं चाग्रे भविष्यति । इदानीं कार्यरूपद्रव्यस्याश्रयभेदेन द्वैविध्यज्ञापनाय सूत्रम् ॥

कार्यरूपद्रव्यं द्विविधं भौमदिव्यभेदात् ॥ १४ ॥

एतद्विभागानुसारेण ज्योतिश्शास्त्रस्य विषय उच्यते ॥

सूर्यादीनां दिव्यपदार्थानां भूपिण्डेन सह सम्बन्धो ज्योतिश्शास्त्रस्य विषयः ॥ १५ ॥

अथैते सूर्यादयो दिव्यपदार्थाः कतिविधा इत्याकां-

च्छायां इंग्लंडीयमतानुसारेण ज्योतिश्शास्त्रस्य कतिचि त्सिद्धांतविषयाः संक्षेपत उच्यंते । तत्रादौ उक्तपदार्थानां द्वैविध्यज्ञापनाय सूत्रम् ॥

केषांचित् स्वतःप्रकाशकत्वात् केषांचित् परतःप्रकाशकत्वात् ते द्विविधाः ॥ १६ ॥

ते दिव्यपदार्था द्विविधा इत्यर्थः । कथं तेषां द्वैविध्यमित्याह केषांचिदिति । यथा दिव्यपदार्था नक्षत्राणि सूर्यवत् स्वतःप्रकाशकानि ग्रहाणां चन्द्रवत् सूर्यतेजसा प्रकाशकत्वात् ते परतःप्रकाशका इति तेषां द्वैविध्यं ॥

ननु चंद्रगतह्रासवृद्धिप्रतीतिश्चक्षुषा भवति शुक्रादीनां ग्रहाणां तादृशप्रतीतिः कथं न भवतीति चेदुच्यते । ग्रहाणां तादृशप्रतीतिर्न नेत्रमात्रेण भवति किंतु तत्र दूरदर्शकयंत्रमपेक्ष्यते । अतस्तत्सहकारेणैव शुक्रादिग्रहाणां स्पष्टरूपेण ह्रासवृद्धिप्रतीतिर्भवति ॥

अथ भूम्याकारज्ञापनार्थं सूत्रम् ॥

भूगोलाकृतिः ॥ १७ ॥

प्रथमाध्याये न्यायप्रकरणे एतत्साधितं । प्रकारांतरेण साधनंत्वग्रे भविष्यति । एवं भुवो गोलाकृतित्वं भास्कराचार्येण यथा साधितं तथा प्रसिद्धमेव ॥

अथ भूभ्रमणसिद्धांतसूचम् ॥

अयं भूगोलः स्वाक्षमभितो भ्रमन्नहोरात्रमुत्पादयति रविं परितो भ्रमंश्च ऋतुभेदानुत्पादयति ॥ १८ ॥

नन्वेवं सति कस्मात् सूर्यो भूमिं परितो भ्रमतीति प्रतीतिर्लोकानां भवतीति चेदुच्यते । गच्छन्नौस्थबालकानां नदीतीरं गच्छतीति प्रतीतिर्यथा भ्रमरूपा तथा उक्तप्रतीतिरपीति बोधं । तथाचोक्तमार्य्यभट्टेन । अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् अचलानि भानि तद्वत्समपश्चिमगानि लङ्कायामिति । भूभ्रमणप्रमाणान्यग्रे वक्ष्यन्ते ॥ अथ चंद्रभ्रमणसिद्धांतसूचम् ।

चन्द्रो भूगोलं परितो भ्रमति ॥ १९ ॥

स्पष्टम् ॥

अथ कथं ग्रहणं भवतीति कदावा भवतीति ज्ञापनार्थं सूत्रम् ॥

पृथ्वीमभितो भ्रमंश्चन्द्रो यदा सूर्य्यपृथिव्योर्म्मध्य
आयाति तदा सूर्य्यग्रहणं यदाच रविचन्द्र-
योर्म्मध्ये भूरायाति तदा चन्द्रग्रहणं ॥ २० ॥

अथ प्रतिमासं पृथ्वीमभितश्चन्द्रस्य भ्रमणेन प्रतिमासं ग्रहणं कुतो न भवतीत्यग्रे विवेचयिष्यते ॥ अथेदानीं ग्रहभ्रमणज्ञापनाय सूत्रम् ॥

ग्रहाः सूर्य्यं परितो भ्रमन्ति ॥ २१ ॥

नन्वेवं सति उक्तभ्रमणस्य चाक्षुषप्रत्यक्षं कुतो न भवतीति चेदुच्यते । यत इयं भूः सूर्य्यं परितो भ्रमति अतो भूस्थेन जनेन वास्तविकी ग्रहकक्षा द्रष्टुं न शक्यते किंतु गणितेन निश्चीयते ॥

अथ यथा भूश्चन्द्रवती तथा सर्वे ग्रहाः कुतो न चन्द्रवन्त इति चेदुच्यते ये ग्रहाः पृथिवीमपेक्ष्य सूर्य्यस्य समीपे वर्त्तन्ते तेषां चन्द्रा एव न सन्ति परंतु ये ग्रहा बहुदूरं वर्त्तन्ते तेषामनेके चन्द्राः सन्तीति ते चन्द्रवंत एव ॥

अथ केषां ग्रहाणां कति चन्द्राः सन्तीति ज्ञापनार्थं सूत्रम् ॥

बृहस्पतेश्चत्वारश्चन्द्राः शनेः सप्त अस्य परितो महाचक्रमपि वर्त्तते ॥ २२ ॥

शनिचक्रं दूरदर्शकयन्त्रमन्तरेण स्पष्टं न दृश्यते । एवंच चक्षुर्मार्गेण यावन्ति नक्षत्राणि दृश्यन्ते तेभ्योऽन्यानि कोटिशो दूरदर्शकयन्त्रेण दृश्यन्ते। अथ मन्दाकिन्यपि दिव्यपदार्थः अतस्तत्स्वरूपज्ञापनार्थं सूत्रम् ॥

मन्दाकिनी नक्षत्रपुञ्ज एव ॥ २३ ॥

ज्ञेया मन्दाकिनी सा नक्षत्रपुञ्ज एवेति दूरदर्शकय-

न्त्रेण ज्ञायते । अन्ये ज्योतिःसिद्धांताः श्री बापूदेवरचितखगोलवर्णने प्रकाशिताः ॥

अथैतदध्यायस्य चतुर्दशसूत्रोक्तविषयानुसारेण भूपिण्डस्थितानां कार्याणां किंचिद्विस्तरेण वर्णनं क्रियते ॥

भूपृष्ठस्थितकार्य्याणां व्यवस्था तत्कार्य्यस्वरूपाणि तत्कार्य्यव्यवस्थायाः कारणानिचेति त्रयो भूपिण्डस्थनिरूपणविषयाः ॥ २४ ॥

अथ भूपृष्ठस्थितकार्य्याणां व्यवस्था का इत्याकांक्षायां सूत्रम् ॥

भूपृष्ठस्थितकार्य्याणां व्यवस्था
भूपृष्ठविद्या ॥ २५ ॥

भूपृष्ठस्थितानां समुद्रनदनदीपुरग्रामपर्वतादिदेशानां परस्परसम्बन्धस्य व्यवस्था भूपृष्ठविद्या इत्यर्थः ॥

अथ नगरस्थित्यनुसारेण नद्यो न वहन्ति परंतु प्रायशो नदीजललाभार्थं तत्तीरे महानगराणि निर्मितानि भवन्ति यथा गङ्गातीरे काशी। किंतु पर्वतव्यवस्थित्यनुसारेण नद्यो वहन्त्येव इत्येतस्य किं कारणमिति जिज्ञासायां तज्ज्ञापनाय सूत्रम् ॥

पर्वताधीननदीप्रवाहात् पर्वतस्थित्य
नुसारेण नद्यो वहन्ति ॥ २६ ॥

पर्वतशब्देन सर्वेषामुच्चभूम्यंशानां ग्रहणं। हिमालयादिषु महापर्वतेषु गङ्गादीनां महानदीनामुत्पत्तेर्नदीप्रवाहाणां पर्वताधीनत्वं अतः पर्वतस्थित्यनुसारेणैव नद्यो वहन्तीति ज्ञेयं। अथ महापर्वते कथं महानद्युत्पत्तिरिति चेत् तज्ज्ञापनार्थं सूत्रम् ॥

महापर्वतशिखराणि शीतानि तत्र काचित् सीमा
वर्त्तते यत ऊर्द्धं वर्तमानानि पर्वतशिखरा-
णि सर्वदा हिमावृतानि भवन्ति ॥ २७ ॥

दूयंच सीमा हिमसीमाख्या । तत्तद्देशस्योष्णतानुसारेण चास्योच्चता भिद्यते । यथा हिमालये समुद्रपृष्ठात हिमसीमाया उच्चता १०००० हस्ताः । युरोपदेशदक्षिण प्रदेशेतु भारतवर्षस्योष्णताया न्यूना उष्णता वर्तते तत्रापि समुद्रपृष्ठाद्धिमसीमाया उच्चता ६००० हस्ताः । ध्रुवसमीपेतु हिमसीमा समुद्रपृष्ठेन समा वर्तते ॥

अथ हिमावृतपर्वतोत्पन्ननदीनां विशेषधर्म्मज्ञापनाय सूचम् ॥

दृष्ट्यभावे ऽपि ग्रीष्मकाले हिमपर्वत
जातानां नदीनां दृद्धिः ॥ २८ ॥

काशीसन्निहितगङ्गानद्या एष धर्म्मः प्रसिद्धः । तस्यच कारणं गङ्गाया हिमालयोत्पन्नत्वन्नैर्ज्ञायते ॥

यथा उष्णकाले गङ्गा वर्द्धते तथा मिश्राख्यदेशे नीलनद्यपि दृद्धिं याति । अथ वक्ष्यमाणं नीलाख्यनदीदृद्धिकारणवर्णमितिहासकर्तुर्यवनस्य हीरादतनाम-

कस्य ग्रन्थादुधृतम् । अयं हीरादतो विक्रमादित्यशका-
रम्भकालात्पूर्वं सप्तविंशत्युत्तरचतुःशतवर्षान्तरे ऽभूत् ।
हीरादत उवाच । नीलाख्यनदीविषये यद्यपि तद्दे-
शीयपण्डिता अन्ये च बहवो मया पृष्टास्तथापि न कि-
ञ्चित् तेभ्यः समाधानं प्रापि । सायनकर्कसंक्रमान-
न्तरं शतं दिनानि नीलाख्यसरिद्दृश्यते । ततो ह्रसमाना
ऽतिशीतकालेऽल्पीयसी जायते । अथ केन कारणेना
न्यनदीविकारविलक्षणो ऽस्यां नीलनद्यां विकारो दृ-
श्यत इति मिश्रदेशवासिषु पृष्टेषु न कस्माच्चन समा-
धायकमुत्तरं लब्धम् । अथ कतिचन यवनाः स्वीय-
पाण्डित्यद्योतनेच्छया नीलनदीदृद्धिविषये त्रीणि व-
र्णनानि चक्रुः । तत्र प्रथममुच्यते । उष्णकाले उद-
ग्वायुर्वहति अनेन तस्याः सम्मेदावरोधे जाते तत्का-
ले सा दृद्धिमेतीति परमेतद्वर्णनं न समीचीनं यतः
तस्मिन्काले उदग्वातवहनाभावेऽपि तस्या दृद्धिः पूर्व-
वज्जायते इति बहुधा दृश्यते किञ्च यदि उदग्वायुर्दृ-
द्धिहेतुः स्यात् तर्हि यावत्यो नद्यः सौम्यवाहिन्यः स्युस्ता-

सामपि तद्वद्विकारः स्यात् तासु चाल्पवेगवत्योऽधिकवृद्धिमत्यः स्युः किन्तु नहि बह्वयोऽन्या उदग्वाहिन्यो नद्यो नीलनदीवद्विकृता भवन्ति । अथ द्वितीयवर्णनम् । वर्णयितृमते समुद्रोऽपि नदी भवति तेनेयं पृथ्वी आवृतास्ति । अतोऽस्या नद्याः समुद्रोत्पन्नत्वादियं वर्द्धते इति परमेतदपिवर्णनमसमीचीनम् । यतः समुद्रविषये यदत्र वर्णितं तत्तु प्रमाणशून्या अस्पष्टार्था किंवदन्ती अस्ति । समुद्रोऽपि नदी भवतीति तु न मया श्रुतम् । यत्तु कदाचित् होमराख्योऽन्ये वा कतिचन प्राचीनकवयस्तादृशमर्थं लब्ध्वा तं स्वकाव्यग्रन्थेषु वर्णयाञ्चक्रुस्तत्तु चमत्कारार्थमेव । तृतीयवर्णनम् । हिमद्रवीभवनेन नदी वर्द्धत इति । नैतदपि सुन्दरम् । यतः इयं नदी याम्यदेशान्निर्गता सौम्यदिशं वहन्ती सती मिश्राख्यदेशमवरोहति । एवं उष्णदेशाच्छीतदेशमायान्त्या एतन्नद्या वृद्धिः हिमाज्जायत इति कथं वक्तुं शक्यते । हिमजातवृद्ध्यनुपपत्तौ बहवो हेतवो भवन्ति येभ्यो यस्य कस्यापि तद्वि-

षये संशीतिविच्छितिः स्यात् । तत्रादौ । नद्युत्प-
त्तिदेशादुष्णो वायुर्वहतीति उक्तवद्ध्यनुपपतौ स्फुटो
हेतुः । अथ च तद्देशीया मनुष्या उष्णतया कृष्ण-
वर्णा भवन्ति किञ्च उष्णदेशप्रिया आकाश्यः सदैव तत्र
वसन्ति क्रौञ्चपक्षिणश्च शीतकाले सौम्यदेशादागत्य तत्र
वसन्ति । परं यदि तत्र किञ्चिदपि हिमं वर्षेत् तदेदं
सर्वं न घटेत ॥

सकलयाऽनया हीरादतस्योक्त्या स उच्चपर्वतस्थो-
ष्णताया उष्णदेशस्थोष्णतायाश्च भेदं नावगच्छेदिति
स्फुटमवगम्यते । स भेदोऽस्य ग्रन्थस्य द्वितीयाध्याये
सप्तविंशसूत्रे वर्णितोऽस्ति ॥

अथ ये पर्वतसम्बधिघटना जानन्ति ते नीलाख्यनदी
ग्रीष्मकाले वर्द्धत इत्यस्य श्रवणमनु इयं नदी हिम-
श्रेण्या उत्पद्यत इति तर्कयेयुः ॥

अथ यथा गङ्गाया हिमस्थानान्निर्गमप्रत्यक्षः तथा-
ऽधुना नीलनद्या अपि प्रत्यक्षोऽभूत् ॥

अथ यो हि हिमालयपर्वते परिभ्रम्य अगाणेयकू-

टान् तदुत्पन्नप्रवाहाँश्च व्यस्तानीक्षेत स तेषु कश्चन क्रमसंस्थितिर्वर्तत इति कदाचिदपि नेक्षेत किन्तु यो हि भङ्गिद्वारा तान् युगपत् पश्येत् स तेषु कश्चन नियतः क्रमः संस्थितिश्चास्तीति जानीयात् । संक्षिप्तवर्णनस्याकांक्षायां तच्च सूत्रम् ॥

भारतवर्षस्योत्तरदिशि पूर्वापरो हिमालयपर्वतस्य विस्तरः ॥ २९ ॥

अस्मिन् पर्वते अनेके मार्गाः सन्ति यानारुह्य याचिणः पारेपर्वतं गन्तुं शक्नुवन्ति । ते घट्टाख्या मार्गा यस्यां हिमावृतपर्वतश्रेण्यां वर्त्तन्ते सा पर्वतश्रेणी हिमघट्टश्रेणीत्यभिधीयते ॥

अथ मुख्यशिखराणामपेक्षायां सूत्रम् ॥

हिमालयपर्वतस्य मुख्यशिखराणि स्वस्वपर्वतश्रेणीसहितानि घट्टश्रेणीदक्षिणदिशि विस्तृतानि सन्ति ॥ ३० ॥

गङ्गानद्युत्पत्तिस्थानं यद् जह्नौचीशिखरं तत्प्रभृति यथाक्रमं मुख्यशिखरनामानि कथ्यन्ते । तथाहि । जह्नौची नन्ददेवी धवलगिरिः गोस्वामिस्थानं कञ्चं-गिरिः चमलारी गिरियुग्मञ्च ॥

अथ तत्सम्बन्धिनदीव्यवस्थासूचम् ॥

तत्तत्पर्वतश्रेण्यन्तर्गता बहवः प्र-
वाहाः क्रमेण एकीभूय तत्र तत्र एकां
नदीमुत्पादयन्ति ॥ ३१ ॥

तथाहि जह्नौचीपर्वतो ऽस्ति यस्योच्चता १७११२ ह-स्तपरिमिता अपिच नन्ददेवी यस्योच्चता १७१२८ ह-स्तपरिमिता । तच्छिखरद्वयसम्बन्धिपर्वतश्रेणीद्वय-मध्ये ये ये गलितहिमोत्पन्नाः प्रवाहाः सन्ति ते क्रमेण मिथः संयुक्ता भवन्ति तत्स्थानस्य कटाहाकृतित्वात् । अतस्तत्र अनेकेषु अनल्पेषु पर्वतेषु गङ्गौचीतीर्थसमी-पस्थकेदारनाथाख्यादिषु सत्स्वपि सर्वे सरित एकीभूय गङ्गानदी भवन्ति ॥

एवमेव नन्ददेवीशिखरोपश्रेण्या धवलगिरिशिख-रोपश्रेण्याश्च मध्ये अनेका नद्यः एकीभूय घर्गटसंज्ञिकां कर्णाटिनदीमुत्पादयन्ति । साच गङ्गया सह स-ङ्गमेति ॥

पुनः धवलगिरिशिखरगोस्वामिस्थानशिखरयोर्मध्ये सप्तगण्डक्याख्याः प्रवाहा वहन्ति तेच मिलित्वा गण्ड-कनदीति संज्ञां प्राप्य गङ्गया सङ्गता भवन्ति ॥

पुनरपि गोस्वामिस्थानशिखरकञ्चंगिरिशिखरयोर्म-ध्ये सप्तकौशिकाख्या नद्यो वहन्ति ताश्चैकीभूय कौशीति आख्यां लब्ध्वा गङ्गया सह मिलन्ति । एवमन्येष्वपि तादृशेषु स्थानेषु भवतीति बोध्यम् ॥

अथ महापर्वतप्रदेशं त्यक्त्वा ता नद्यो गङ्गासङ्गात् प्राक् कीदृशे प्रदेशे वहन्तीत्याकांक्षायामाह ॥

एता नद्यो हिमाचलसमान्तरदेशे व-र्त्तमानां सैकतपाषाणपर्वतश्रेणीं भि-त्त्वा स्वस्वसरणिं कुर्वन्ति ॥ ३२ ॥

इयं सैकतपाषाणपर्वतश्रेणी उभयतोऽपि भूपृष्ठात् द्विशतीहस्तप्रभृतिचतुःशतीहस्तपर्यन्तोच्चा भवति । पुनः सूचयति ॥

सैकतपाषाणपर्वतश्रेण्या उत्तरभागे धूनाख्यप्रदेशाद्दक्षिणदिशि भावराख्यस्तदधःतराईसंज्ञकश्चेति प्रदेशा भवन्ति ॥ ३३ ॥

हिमालयविस्तृतिसममितिरेकोनचत्वारिंशत्क्रोशा भवन्ति । तच्च प्रत्येकं चयोदशक्रोशपरिमाणास्त्रयो विभागाः स्वदेशविशेषानुसारतः क्रमेणाधरमध्योर्ध्वसंज्ञाः स्युः । तत्राधरविभागे तराईसंज्ञको भावरसंज्ञकश्च सैकतपाषाणपर्वतश्रेणीच तत्सम्बन्धिनो धूनाख्यप्रदेशाश्च वर्त्तन्ते । अयं विभागो भूपृष्ठप्रभृतिः समुद्रपृष्ठात् २७०० हस्तोच्छ्रायो यः प्रदेशस्तदवधिर्भवति । ततः समुद्रपृष्ठात् ६७०० हस्तोच्छ्रायो यः प्रदेशस्तदवधिर्मध्यविभागो भवति । ऊर्ध्वविभागः शेषः ॥

अथ पर्वतशिखरप्रदेशाः शीतला भवन्तीति सप्त-विंशसूत्रे प्रोक्तं। तेन यदि शिखरदेशे हिमं स्यात् तलदेशेचात्युष्णो वायुः स्यात्तर्हि तलाच्छिखरपर्यन्तं प्रदेशे उत्तरोत्तरमवश्यं शीतलो भवेदिति स्पष्टतरं। अथ कतिचन जन्तव उष्णदेशप्रिया अन्येच शीतप्रिया भवन्ति। एवमोषध्योऽपि। तथा जन्तव ओषध्यश्च स्वस्वप्रियप्रदेशे पुष्टिमायान्तीति सर्वस्मिन् जगति स्थितिरस्तीत्यवगतमपि तत्सर्वं हिमालयप्रदेशे दृष्टान्तितं। तत्र सूत्रयति ॥

हिमालये ऽन्येषुचोच्चपर्वतेषु प्रदेशोच्चता-
विशेषे ओषधीनां जन्तूनाञ्च विशेषा
भवन्ति ॥ ३४ ॥

तथाहि। ओषध्यः। अधरविभागे सालः शिंशपा तुन्दः पलाशो वटः पिप्पलश्चेत्यादयो भवन्ति। मध्यविभागेच पूर्वोक्तविलक्षणा इङ्गुदखण्डीयादिदेशेषु प्रसिद्धा दृश्या भवन्ति येचोष्णदेशे नोत्पद्यन्ते। अथ इङ्-

लण्डीयादिदेशानामप्युत्तरतो ऽतिशीतदेशेषु प्रसिद्धा ये वृक्षास्तत्सजातीया देवदारुभूर्ज्जादयो वृक्षास्तदूर्ध्वभागे उत्पद्यन्ते ॥

जन्तवस्तु अधरदेशे उष्णदेशप्रिया वसन्ति किन्तु मध्यदेशे तादृशाः प्राणिनो वर्त्तन्ते ये ऽधरदेशे उष्णताधिक्यात् स्थातुं न शक्नुवन्ति । अथाधरमध्यदेशयोरपि उष्णताबाहुल्यात् स्थातुमसमर्था जन्तव ऊर्ध्वदेशे वसन्ति । एवमेव अधरप्रदेशे हस्तिनः खड्गा व्याघ्रा हरिणाश्चेत्यादयो वसन्ति । मध्यदेशे न हस्तिनो न खड्गा नवा व्याघ्राः । तत्र केवलमेका हरिणजातिर्वसति । ऊर्ध्वदेशेतु नैतेषां पूर्वोक्तानां हस्त्यादीनां कश्चन जन्तुरास्ते किन्तु तत्र पर्वतीयमेषा पर्वतीयाजाश्चेत्यादयस्तिष्ठन्ति । एवमधरप्रदेशजाः काका नोर्ध्वदेशे दृश्यन्ते । तादृशाः कतिपये मध्यदेशे वसन्ति ॥

एवं हिमालये तलाच्छिखरपर्यन्तमुत्तरोत्तरं शैत्यदृद्धेः तादृशा देशविशेषा भवन्ति ये प्रायः समानभूम्यां सुमहति देशे भवन्ति ॥

अथ युरोपीयाख्यैः कल्पितानां भूपृष्ठविभागानां वर्णनम् ॥

एशिया आफ्रिका यूरोपा अमेरिकाख्या-
श्चत्वारो भूपृष्ठखण्डा ज्ञेयाः ॥ ३५ ॥

भूपृष्ठखण्डा इति । पृथ्वी गोलप्राया भवति यस्या व्यासः किञ्चित्सान्तरश्चतुस्सहस्रक्रोशमितो भवति । भूपृष्ठस्य किञ्चिदधिकौ द्वौ तृतीयांशौ समुद्रेण व्याप्तौ भवतः । शेषः स्थलभवति । तस्यैव चत्वारः खण्डा इत्यर्थः । अथ तल्लक्षणानि ॥

भारतवर्षं यत्र वर्त्तते स एव एशियाख्यखण्डः इङ्गलण्डसंज्ञदेशो यत्र स एव यूरोपाख्योऽपिच एशियाख्यखण्डस्य प्रतीच्यां दिशि आ-

फ्रिकायूरोपाखण्डे वर्त्तते आफ्रिकाखण्डस्य-
चोदीच्यां दिशि यूरोपाखण्डं वर्त्तते भारत-
वर्षाकुदलान्तरे अमेरिकाख्यखण्डन्तिष्ठति
इदमुत्तरध्रुवसमीपप्रदेशादि दक्षिणध्रुवा-
न्तिकप्रदेशपर्यन्तं विस्तृतं भवति ॥ ३६ ॥

सर्वे जलस्थलस्थाः प्रदेशा भूपृष्ठभङ्गिप्रदेर्शनेन ज्ञा-
यन्ते । अथ कतिचिद्देशा उष्णा भवन्ति कतिचना-
नुष्णा इत्यच मुख्यो हेतुरुच्यते ॥

रविकिरणलम्बरूपतिर्यक्पतनानुसा-
रतस्तत्तद्देशस्योष्णता ॥ ३७ ॥

यो देशो निरक्षासन्नो भवति तच रविकिरणा ल-
म्बरूपाः पतन्ति अतः स भारतवर्षवदुष्णो देशो भ-
वति । यश्च देशो ध्रुवासन्नो भवति तच रविकिर-
णास्तिर्यक् पतन्तीति स देशः शीतो भवति यथा इङ्ग-
लण्डाख्यः ॥

पर्वतेभ्यः सरित उत्पद्यन्ते यथा हिमालयाद्गङ्गादय उत्पन्ना इति पूर्वमुक्तं । आफ्रिकादेशे ऽल्पाः पर्वता इति तत्र सरितो ऽल्पा अतः स देशो निष्फलप्रायः ॥

भूगोलग्रन्थेषु विषयाणां ग्रामाणाञ्च दिशो लिख्यन्ते तत्तद्देशसम्बन्धीनि नीतिधर्माचरणानि राज्यप्रकरणानिच प्रदर्श्यन्ते । तान्यत्र विस्तरभयान्न लिख्यन्ते ॥

इति भूपृष्ठव्यवस्थाप्रकरणं समाप्तम् ॥

अथ भूपृष्ठव्यवस्थां संक्षेपेणाभिधाय तत्रत्यभौतिककार्याणि तदीयकारणानिच निरूप्यन्ते । भौतिककार्यसामान्ये कारणानि परमाणवः । तेषां विशेषधर्मनिरूपणाय सूत्रम् ॥

अथ परमाणुतदाकर्षणोत्सारणजडत्वजिज्ञासा ॥ ३८ ॥

परमाणवति । भौतिककार्यमात्रमतिसूक्ष्मांशैर्भे-

यमस्ति तेचांशा मनुष्यशक्तिना नाश्या न भवन्ति यथा । लोहादिधात्वंशः सहस्रवारं चुर्णो भग्नश्छिन्नो गलितो विकृतो ऽपि सदा यथावत् दर्शयितुं शक्यः । तच ये सूक्ष्मतमा अंशा अभेद्या अछेद्याश्च भवन्ति ते परमाणुसंज्ञकाः स्युः ॥

तदाकर्षणेति । परमाणवः पृथक्भूत्वा कार्य्यीभूय वा अन्यपरमाणून् प्रति जिगमिषवो भवन्तीति दृश्यते । यथा पाषाणादिकार्य्यस्यांशाः केनचिद्बलेन संयुक्तास्तिष्ठन्तीति दृश्यते । यथा वा पतितः पाषाणः केनचिद्बलेन भूम्या सह संयुक्तस्तिष्ठतीति दृश्यते । यथा वा समुद्रश्चन्द्रमसि जिगमिषुर्दृश्यते । अच कारणं तत् आकर्षणाख्यं स्यात् ॥

उत्सारणेति । परमाणूनां परस्पराकर्षणे क्वचित्प्रतिबन्धो दृश्यते । यथा यचोष्णतायाः प्रवेशस्तच । तदा परमाणूनां मिथो विश्लेषो लक्ष्यते । तथाहि । हिममुष्णता प्रविशेत्तर्हि जलमुत्पद्यते । अपिच जल-

मुष्णता प्रविशेत्तर्हि वाष्प उत्पद्यते । अत्र कारणा-
मुत्सारणाख्यं स्यात् ॥

जडत्वमिति । यथा कुम्भकारस्य चक्रं भ्रमणकाले प्रथमं भ्रामकयत्नं रुणद्धि किन्त्वनन्तरं क्रमशः तद्य-त्नशक्त्यनुसारेण शीघ्रगतिं लभते तथाच स्वशैघ्र्यानु-सारेण स्वगमनप्रतिरोधयत्नं प्रतिकरोति तथैव सर्वाणि कार्य्याणि परमाणवश्च स्थैर्यगमनयोरपेक्षायां केनचि-दविकारेणुत्वेन विशिष्टा इति दृश्यते । तत्र कारणं जडत्वसंज्ञं स्यात् ॥

अथ परमाणवाकर्षणादिधर्मविचारात् इन्द्रियग्राह्य-गुणवत्त्वंसारधर्मज्ञानसम्भवो यथाशक्ति प्रदर्श्यते ॥

इन्द्रियग्राह्यगुणवत्त्वंसारो ऽयं
परमाणुनिर्मितः ॥ ३९ ॥

लोहादिधात्वंशः सहस्रवारं चुर्णो भस्मो गलितो विकृतोऽपि सदा यथावत् दर्शयितुं शक्य इति पूर्वं

कथितम् । यद्यपि वृक्षपचादीनां पक्षिपक्षादीनां वा तादृशो धर्मो नास्ति यतो जीवित्वसाधनविशिष्टपदार्थकर्तृत्वमस्मदादीनामसम्भावि तथापि वृक्षादीनां ज्वलनादिकाले ऽप्येको ऽपि परमाणुर्न नश्यतीति रसायनप्रकरणे प्रदर्श्यते ॥

अथ परमाणुपरिमाणमुच्यते ॥

परमाणवो ऽति सूक्ष्माः ॥ ४० ॥

तचैकं प्रमाणमुच्यते तद्यथा सुवर्णकारास्ताडनेन सुवर्णपत्राणि तथा सूक्ष्मीकुर्वन्ति यथा ३६०००० संख्याकानां तेषां पत्राणां स्वोपर्युपरि न्यस्तानां पिण्ड एकाङ्गुलमात्रपरिमितो भवति । तथापि प्रत्येकं पत्रे परमाणुपरिमाणादधिकघनत्वमवगम्यते यतो राजततारे लिप्तस्य स्वर्णस्य घनत्वं तादृशपत्रघनत्वान्न्यूनं लक्ष्यते । तस्यापि घनत्वस्य परमाणुपरिमितत्वे मानाभावः ॥

परमाणूनाम्परिमाणं सर्वपरिमाणेभ्यः सूक्ष्मं भवति

तच्च न द्व्यणुकपरिमाणोत्पत्तौ कारणं अणुजन्यस्या-
णुतरत्वप्रसङ्गात् किन्तु तचान्यदेवेश्वरेच्छादिकमगत्या
कारणं वक्तव्यमिति न्यायसिद्धान्तः । अस्मत्सिद्धान्त-
स्तु तत्तज्जातीयपरमाणूनां तत्तज्जातीयसर्वद्रव्येभ्यः
सूक्ष्मतरत्वे ऽपि तत्तज्जातिनियतमहत्वस्वीकारे न कि-
ञ्चिदपि बाधकं । एवञ्च परमाणुपरिमाणं द्व्यणुक-
परिमाणे एकं कारणमित्यस्योपपत्तिरग्रे वक्ष्यते ॥

यत्तु निष्परिमाणा एव परमाणवो विरोधनामको
वक्ष्यमाणधर्मश्च तेषां स्वाभाविक एवेति यूरोपदेशीयस्य
बास्कविकाख्यस्य मतं । साक्षाद्बाधविरहे ऽपि भौ-
तिकवस्तुतत्त्वनिर्णये ऽल्पतरोपकारकत्वात् अस्मन्मता-
पेक्षया न वरम् । अत उच्यते ॥

भौतिकपदार्थाः परिमाणरहिताः
कदापि न सन्ति ॥ ४१ ॥

यथा तूलराशिः सङ्कोचकव्यापारेणाल्पतरपरिमाणः

कर्त्तुं शक्यते नतु निष्परिमाणः तथा सर्व एव भौतिकपदार्थाः परिमाणं कथमपि न त्यजन्ति । स एष स्वीयपरिमाणापरित्यागलक्षणो धर्मो विरोध इत्युच्यते । तत्स्वरूपञ्चैकचैकदा द्वयोर्बहूनां वा द्रव्याणां स्थित्यभावः । तत्रोदाहरणान्युच्यन्ते ॥

जलेन परिपूर्णे पात्रे पाषाणः प्रक्षिप्यते चेत् पाषाणाय अवकाशं दत्त्वा जलं बहिर्गच्छति ॥

एका काचनलिका अङ्गुलीप्रतिरुद्धोपरिमुखी अनावृताधोमुखीच जले निमज्जिता सती जलेन न पूर्यते तदन्तर्गतवायुना जलस्य विरोधात् । यदाच वायुनिर्गमनाय अङ्गुलिनिष्कासनं क्रियते तदा बहिःस्थितजलपृष्ठपर्यन्तं जलपूर्णा भवति ॥

वायुपूर्णे ऽधोमुखे पात्रे जले स्थापिते किञ्चिज्जलमन्तर्गच्छति परन्तु यावत् तत्पात्रमुखमुपरि न कृत्वा वायोर्गमनमार्गो न कृतस्तावत् तत्पात्रं जलेन पूर्णन्न भवति वायुविरोधात् । अन्तर्वर्त्तमानदीपे ऽधोमखे

वायुपूर्णे पात्रे जले निमज्जिते ऽपि अतिगम्भीरजल-तले ऽपि स्थितो दीपः किञ्चित्कालं ज्वलति । एवं र-ज्ज्ववलम्बिताधोमुखवायुपूर्णमहापात्रमध्यस्थायिनो म-नुष्या जलमग्नवस्त्वानयनाय समुद्रतलं यान्ति । अ-स्माद्धेतोस्तत्समुद्रावतरणमहापात्रं घण्टाकारत्वान्नि-मज्जनघण्टेत्युच्यते ॥

अथ परमाणूनां पृथगवस्थानाभावे हेत्ववश्यम्भावा-दनुमीयते ॥

परमाणवः परस्परमाकर्षन्ति ॥ ४२ ॥

तेषाम्परस्पराकर्षणमस्तीति भावः । भिन्नानां त-दुत्पन्नकार्याणामपि परस्पराकर्षणमस्ति । तच्चोदा-हरणानि ॥

सरसः स्थिरजले प्लवमाना दृढकाष्ठखण्डा नौका वा मिथः सङ्गता भवन्ति सङ्गमानन्तरं स्वतः पृथक् न भवन्ति ॥

यथा भारतवर्षे प्रस्तरा भूकेन्द्राभिमुखं पतन्ति अव-

लम्बश्च केन्द्राभिमुखमेवावलम्बते तथैव भारतवर्षात्कु-दलान्तरे ऽपि घटते । अत एव कपाटलग्नस्वच्छकाचबहिर्भागे वर्त्तमाना मक्षिका इव कुदलान्तरस्था मनुष्या अस्मदभिमुखं भूलग्नपादा वर्त्तन्ते । उक्तञ्च भास्कराचार्य्यैर्गोलाध्याये ॥

सर्वतः पर्वतारामग्रामचैत्यचयैश्चितः
कदम्बकुसुमग्रन्थिः केसरप्रसरैरिव ।

ननु यथा कदम्बकुसुमग्रन्थौ केसराणां खचितत्वात्ते ततो न पतन्ति तथा नहि मनुष्या भुवि खचिताः । किमु तर्हि कुचतुर्थभागे कुदलान्तरेच स्थिता मनुष्या न पतन्तीत्यत आहुः ॥

यो यच तिष्ठत्यवनीं तलस्थाम्
आत्मानमस्या उपरि स्थितञ्च ।
स मन्यते ऽतः कुचतुर्थसंस्था
मिथश्च ते तिर्यगिवामनन्ति ।
अधः शिरस्काः कुदलान्तरस्थाश्-
च्छाया मनुष्या इव नीरतीरे ।

अनाकुलास्तिर्यगधः स्थिताश्च
तिष्ठन्ति ते तच्च वयं यथाच ।

परमाणूनां एककेन्द्रगामित्वादेव पृथ्वी गोलरूपा जाता । एवं संगताः कुज्झटिकांशा अपि गोलरूपा दृश्यन्त । तेषुच भूमिप्राप्तेषु तेषां गोलत्वं सुतरां नश्यति परन्तु द्रवीकृतसीसके उच्चस्थानाच्चालनीद्वारा पातिते तद्बिन्दवो घनीभूय भूमिं प्राप्ता गोलत्वं न त्यजन्ति । अनयैव युक्त्या व्याधा गोलरूपान् सूक्ष्मसीसककणान् पक्षिहननार्थं निर्मायन्ते । अद्रवीकृतसीसकांशा उच्चस्थानात्पातिता अपि गोलत्वं न प्राप्नवन्ति अत एव पृथ्वी चन्द्रः सूर्यो ग्रहाश्च पूर्वं कस्मिंश्चित् काले द्रवीभूता आसन् इत्यनुमीयते । अपिच परस्पराकर्षणरूपः सामान्यधर्मोऽपि तेषु वर्त्तते इत्यनुमीयते ॥

ननु यदि सर्वमच भूकेन्द्रम्प्रति जिगमिषुः स्यात्तर्हि धूमः कथमूर्ध्वं गच्छतीति चेदुच्यते । धूमः स्वय-

मवोर्ध्वं न गच्छति किन्तु भूसमोपस्थो वायुस्तस्माद्गुरु-
तरो ऽस्तीति सो ऽधो गत्वा धूममुत्थापयति यथा
घटस्थजले तले मुक्तं तृणं ततो गुरु जलमुत्थापयति ॥

परस्पराकर्षणरूपो धर्मो ऽतिदूरप्रदेशे ऽपि न न-
श्यति । तत्रोदाहरणं । चन्द्रो यद्यपि १०५९०० एतत्क्रोशमितदूरदेशे वर्त्तते तथापि स्वकीयाकर्षणेन स्वाधःस्थितसमुद्रस्य नीरमुत्थापयति । एवं समुद्रस्य वृद्धिह्रासौ जायेते । तथैवातिदूरे वर्तमानो ऽपि सूर्यः समुद्रमाकर्षति । यदा पृथ्वी सूर्यः चन्द्रश्च एकस्यां सरलरेखायामायान्ति तदा सूर्यचन्द्रयोराकर्षणैक्या-त्समुद्रो ऽधिकं वर्द्धते ॥

अथ यद्यप्यतिदूरप्रदेशे ऽपि आकर्षणरूपो धर्मो न नश्यति तथापि दूरत्वेनाल्पीक्रियत इति सूचयति ॥

भौतिकपदार्थानां परस्परसन्निधानतारत-
म्यात् परस्पराकर्षणतारतम्यं भवति यथा

दीपसामीप्यदूरत्वविशेषात्तेजस
आधिक्यन्यूनत्वविशेषः ॥ ४३ ॥

हस्तपरिमितवर्गाकारकाष्ठखण्डं स्थापयित्वा अर्द्धद-
ण्डदूरस्थेन दीपेन प्रकाशयेत् तदा तत्काष्ठखण्डस्य
पश्चात् द्वितीयं द्विहस्तपरिमितकाष्ठखण्डं स्थापयेत्त-
र्हि प्रथमखण्डस्य च्छायया द्वितीयखण्ड आच्छादित
एव भविष्यति । अथ द्विहस्तपरिमितभुजवर्गे एक-
हस्तभुजपरिमिताः चत्वारो वर्गा भवन्ति यतो नह्यत्र
भुजस्य केवलं दैर्घ्यं वर्द्धते येन वर्गो द्विगुणः स्यात् किन्तु
विस्तारोऽपि तथैव वर्द्धिमेति अतः स चतुर्गुणो
भवति'। अतस्तेजः स्वनिष्काशनस्थानाद्द्विगुणेऽन्तरे
चतुर्गुणप्रदेशे विस्तृतत्वात्तस्य तेजस्त्वं स्वचतुर्थांशसमं
भवति । एवमनया युक्त्या त्रिगुणेऽन्तरे तत्स्वनवमां-
शतुल्यं जायते । एवमग्रेऽपि । एवं तेजसो विस्तृति-
विशेषात्तत्तेजस्त्वह्रासविशेषः तथा भवति यथा 'कति-

पयैर्मनुष्यैः समं विभज्य ग्राह्यासु कतिषुचिन्मुद्रासु यथा मनुष्यसंख्याधिक्यविशेषात्प्रतिमनुष्यं समं तन्मुद्राभाग-न्यूनताविशेषः । वस्तुतः प्रकाशैष्णयाकृष्टिध्वन्यादयः कदम्बगोलकन्यायेनोत्पद्यमानाः सर्व एव गुणाः पूर्वोक्तान्योन्यपिदधद्वर्गच्चेचदृष्ट्यनुसारतो स्वीयभावह्रासं यान्ति । एवमेवोक्तनियमानुसारेण यस्य वस्तुनो भारः समुद्रतीरे सहस्रपलप्रमाणस्तस्यैव भारः किञ्चिदुच्चप्रदेशे शैले पञ्चभिः पलैर्न्यूनो भवति । इदं स्थितिस्थापकविशिष्टतुलया परीक्ष्य साधितमस्ति । तादृशतुलाया उच्चपर्वते यावद्दैर्घ्यं तदपेक्षया समुद्रतीरेऽधिकं भवतीत्येतेन तच्च भाराधिक्यं द्योत्यते । अथोच्चपर्वते यो भारह्रासो भवति तत्प्रमाणानुसारेण गणिते कृते वस्तुनः सहस्रपलप्रमाणो भारः भुवं प्रति प्रावण्यं वा चन्द्रकक्षायां विंशतिमाषप्रमाणं सिद्ध्यति । एतद्वर्णनमुत्तरभागे पुनः करिष्यते ॥

यदा घटाज्जलं पात्यते तदा घटकृताकृष्टिहेतोस्त-

ज्जलं नहि तत्क्षणादेव तस्मात्पृथग्भवति । किन्तु तदाकर्षकभाण्डबहिर्देशे संलग्नं भूत्वा पतति। अत एव जले यद्भाण्डकृताकर्षणं तन्निरसनाय नलीविशिष्टानि पात्रविशेषाणि निर्मीयन्ते । तादृशानि पात्राणि कमण्डल्वाख्यानि प्रायो भारतवर्षीयतपस्विनां निकटे दृश्यन्ते । अथ यदि नलीरहितपात्रात्तथा जलं पातयितुमिष्यते यथा तत्पात्रबहिर्देशे ऽलग्नं सत् पतेत् तदा पात्रमुखे जलपतनस्थले काचादिदण्डं संस्थाप्य पातयेत् तथाच तत्पात्रकृताकृष्टिविरुद्धं दण्डकृताकर्षणं भवति तेन दण्डद्वारा सर्वं जलं पात्रालग्नं सत् बहिः पतति ॥

जलकणा मिथः संलग्ना भवन्ति यथा सूक्ष्मा सूची अपि जलपृष्ठे मन्दं मोचिता सती तत्र प्लवते । तत्सूचीभारो जलपृष्ठं भेत्तुं न शक्नोति । एवमेव अल्पाः कीटमक्षिकादयः पानीयपृष्ठोपरि वार्यालिप्ता गन्तुं शक्नुवन्ति ॥

अन्योन्यलग्ने जलमग्नाधरभागे द्वे काचादिपात्रे स्वम-

ध्यदेशे ऽन्योन्यसान्निध्यानुसारतो जलमाकर्षतः । तेन जलं स्वपृष्ठादूर्ध्वं गच्छति । एवमेव पानीयस्य मस्यास्तैलस्य वा बिन्दुः पुस्तकपार्श्वभागे पतितः सन् शीघ्रं पत्रान्तः प्रविश्य दूरं प्रसरति । अथच दीपवर्त्तिर्द्वित्राङ्गुलप्रमाणदूरदेशादपि तैलमाकर्षति ॥

परमाणवः स्वान्तर्गतोष्णतया विरला भवन्तीत्यक्तं प्राक् तस्मिन् विषये किञ्चिद्विस्तरेण कथनाय सूचम् ॥

परमाणवः स्वान्तर्गताया उत्सारणकर्त्र्या उष्णताया न्यूनत्वानुसारेण सान्द्रीभूय आधिक्यानुसारतो वा विरलीभूय अद्रवा द्रवरूपा वायुरूपाश्च जायन्ते ॥ ४४ ॥

परं नहीदानीमुष्णतायाः स्वरूपमुच्यते किन्तु सा केवलं उत्सारणे हेतुर्भवतीत्युच्यते ॥

भौतिकपदार्थे यथायथोष्णता वर्द्धते तथातथा तत्परमाणूनां विरलीभवनात्स पदार्थो विस्तृतो भवति ।

एवं घनपदार्थः पूर्वं विस्तृतो भूत्वा मृदुर्भवति । ततो विलीयते । अन्ते तत्परमाणवो ऽतिविरला भवन्ति येन स पदार्थः स्थितिस्थापकविभ्रिष्टः प्रवाही नाम वायुरूपो जायते । अथैतादृशो वायुरूपस्तदन्तर्वर्त्युष्णताया निष्काशनेन पुनस्स्वीयावस्थे प्राप्नोति ॥

तदित्थं । हिमे उष्णीकृते तत्पानीयं जायते पानीयेचात्युष्णीकृते तद्वाष्पं जायते । अथ पुनर्वाष्पे शीतीकृते तत्पानीयं भवति । पानीयेच शीतीकृते तत्पनर्हिमं जायते । एवमेकस्यैव पदार्थस्य हिमत्वं पानीयत्वं वाष्पत्वञ्चेति त्रयो भावा भवन्ति । एवमन्य ऽपि भौतिकपदार्था उष्णतया नानाभावा भवन्ति किन्तु केचन अधिकोष्णतामपेक्षन्ते केचन न्यूनामिति विशेषः । अन्यथा अद्रवा द्रवरूपा वायुरूपाश्च एकस्मिन्नेव काले न दृश्येरन् ॥

उष्णतामापनार्थमुष्णतामापकाख्यमेकं यन्त्रं क्रियते । तन्निर्माणविधिरग्रे वक्ष्यते ॥

अथाकर्षणोत्सारणयोर्विशेषतो ये तदाधीनधर्मविशेषा भवन्ति तत्कथनार्थं सूत्रम् ॥

आकर्षणोत्सारणयोर्विशेषतः सञ्जाता धर्मविशेषाः स्फटिकाकारग्रहणशीलत्वं सान्तरत्वं दृढत्वं काठिन्यं स्थितिस्थापको भङ्गुरता ताडनवर्द्धनीयता प्रसरच्छमता स्नेहाकर्षणञ्चेति ॥ ४५ ॥

स्फटिकाकारग्रहणशीलत्वमिति । यदा यदा लवणजातिर्जलसंयोगाद्विलीयते तदा तदा उष्णतया तच्चत्यजले शोषिते सा एकविधमेवाकारं गृह्णाति नान्यमिति केषाञ्चित्पदार्थानां सर्वदा स्वीयाकारनियमविशिष्टोत्पत्तिदर्शनादिदमनुमीयते यत् परमाणवः कार्यारम्भकाले प्रतिपरमाणून् सर्वावयवावच्छेदेन नाकर्षन्ति किन्तु केनचिदेकेनैवेति । तच्च यो धर्मः स स्फटिकाकारग्रहणशीलत्वसंज्ञः स्यात् प्रायः स्फटिकविशेषे तद्धर्मस्य दर्शनात् ॥

सान्तरत्वमिति । कठिनपाषाणस्याप्यवयवाः सान्तरा भवन्ति । अत एव सैकतपाषाणविशेषस्य पानीयशो-धने उपकर्त्तृत्वम् । तच्च कारणं सान्तरत्वसंज्ञं स्यात् ॥

दृढत्वमिति । घनहस्तपरिमितपारदस्तन्मितादेव पानीयात्स्वल्पान्तरचतुर्दशगुणो गुरुर्भवति । अस्मा-दिदमनुमीयते यद्भौतिकपदार्थस्योद्दिष्टावकाशे स्वगुरु-त्वधिक्यानुसारेण परमाण्वाधिक्यं भवतीति । तत एव स पदार्थो दृढतरावयव इत्युच्यते । अथ भौतिकपदार्थे स्वान्तर्गतोष्णताधिक्येन विस्तृतेऽप्युष्णतानिष्काशनेन स-ङ्कुचितेऽपि वा तत्परमाणूनामविकृतत्वात्तद्गुरुत्वं कि-ञ्चिदपि विकृतिं नैति किन्तु तस्य घनहस्तादिमितदेशे परमाणुसंख्याया विकृतत्वादुद्दिष्टघनाङ्गुलादिपरिमिते तस्मिन् विकारो भवति । अत्र यः सापेक्षो धर्मविशेषः परमाणुन्यूनाधिक्यात्मकः स दृढत्वसंज्ञः स्यात् ॥

द्रव्याणां जातीयगुरुत्वस्य निर्णयाय जलं मापकं भवति यथाग्रे वक्ष्यते ॥

काठिन्यमिति । येन धर्मेण एकं द्रव्यमपरस्य पृष्ठं छिनत्ति स धर्मः काठिन्यसंज्ञः स्यात् । अद्यावधिज्ञातानां द्रव्याणां मध्ये हीर एव कठिनतमो ऽस्ति यः सर्वाणि ज्ञातद्रव्याणि छेत्तुं शक्नोति ॥

स्थितिस्थापक इति । अन्यथाकृतस्य पुनस्तादवस्थ्यापादकः स्थितिस्थापकः ॥

भङ्गुरतेति । येन धर्मेण कठिनमपि द्रव्यं स्वल्पेनाप्याघातेन भग्नं भवति स भङ्गुरत्वसंज्ञः स्यात् । यथा । काचः लोहपृष्ठं छिनत्ति अतः स लोहमपेक्ष्य कठिनतरः तथापि काचः स्वल्पाघातेन भग्नो भवति ॥

ताडनवर्द्धनीयतेति । येन धर्मेण सुवर्णादि ताडितं पत्ररूपं गृह्णाति स धर्मः ताडनवर्द्धनीयतासंज्ञः स्यात् ॥

प्रसरच्छमतेति । यद्धर्मद्वारा सुवर्णादि तारारूपं छमते स धर्मः प्रसरच्छमतासंज्ञः स्यात् ॥

स्नेहाकर्षणमिति । महाभारं द्रव्यं सूच्मलोहसूच-

मवलम्ब्य स्थातुं शक्नोति परन्तु अल्पभारं केवलं सू-
च्यसीसकसूचमवलम्ब्य स्थातुं कल्पते । तथाच यः
पदार्थविशेषे विशेषमासादयन् धर्मः पदार्थस्य उ-
भयत आकर्षणे प्रतिबन्धको भवति स स्नेहाकर्षण-
संज्ञः स्यात् ॥

अथ परमाणुनिर्मितकार्याणि कदाचित् स्थिराणि
तिष्ठन्ति कदाचिच्च गच्छन्ति । अतो गमनधर्मविचा-
रः क्रियते ॥

द्रव्याणां स्थानविकारो गतिः ॥ ४६ ॥

सा च सरलवक्रादिभेदादनेकधा । अधः पततो द्र-
व्यस्य मार्गे या गतिर्लोक्यते सा सरला । तिर्यक् प्र-
क्षिप्तस्य द्रव्यस्य मार्गे या सा वक्रा । भुवि पतत: प्र-
स्तरादेर्या गतिः सा वर्द्धमानाख्या । उत्क्षिप्तस्य प्र-
स्तरादेरधोगमनारम्भकालात्प्राग् या गतिः सा क्षी-
यमाणाख्या ॥

अथ गतिः कस्मादुत्पद्यते कस्माच्च नश्यतीत्युच्यते ॥

येन गतिर्जायते येन वा ह्रास-
मेति तद्वलसंज्ञं स्यात् ॥ ४७ ॥

कुलालचक्रं भ्रमणारम्भकाले स्वभ्रामकबलविरोधि भवति ततः स्वस्थैर्यस्यापि रोधकं भवतीत्युक्तं प्राक् । तथैव अकस्माद्रथस्य गमनमनु तत्स्थो मनुष्यः पश्चात्पतति तथाच शीघ्रं गच्छतो रथस्य स्थैर्यमनु तत्र तिष्ठन् मनुष्योऽग्रे पतति । तथैवच नद्यां गच्छन्ती नौर्यदाकस्मात्तीरे लगति तदा ततः शीघ्रमवरोढुमुत्तिष्ठन्तोऽज्ञानिनस्तीरे पतन्तीति प्रसिद्धम् ॥

अथ द्रव्याणां स्थिरता स्वाभाविकीत्ति अथवा तेषां गतिरित्यत्रोच्यते ॥

द्रव्यस्य स्थिरता समानसरलग-
तिश्च सदातने भवतः ॥ ४८ ॥

अयमर्थः । नहि किञ्चन द्रव्यमुपाधिमन्तरा गतिमङ्गवति नच गतिं प्राप्तं तां त्यजति नच भिन्नां दिशं गच्छति ॥

अयोगोले भूमौ प्रक्षिप्ते यदि भूः समा न स्यात्तदा तद्गमनं झटिति विनश्येत् । यदि समा स्यात्तर्हि गमनप्रतिरोधस्याल्पत्वात् तद्गमनमधिककालेन नश्येत् । अन्ते तु नश्येदेव अत्र प्रतिरोधाभावासम्भवात् । गमनप्रतिरोधकाभावस्तु खगोल एव तत्र ग्रहाणां गमनङ्कदापि विकृतं न भवति ॥

सम्मुखदिश्येव कस्मिंश्चिल्लक्ष्ये मोचितः शरो भूम्याकृष्टिहेतोरुत्तरोत्तरमधो याति परन्तु यदि भूवायुः स्थिरः स्यात्तर्हि नहि तस्य गतिरुत्तरतो दक्षिणतो वा भवेत्किन्तु सम्मुखदिश्येव । यदि गतेरयं धर्मो न स्यात्तर्हि नहि कश्चन शरं निश्चयेन लक्ष्ये प्रापयितुं शक्नुयात् ॥

सपाषाणे भिन्दपाले भ्रामिते यदा पाषाणस्ततो नि-

गच्छति तदा चापमौर्विकातो मुक्तः शर इव स सरलं व्रजति परन्तु पाषाणभ्रममण्डलस्य यस्मात्स्थानात्तन्निर्गमे स लक्ष्ये लगेत् तत्स्थाननिर्णयो ऽभ्यासतोऽपि दुःशको ऽतो ऽनेन लक्ष्यहननमपि दुःशकम् ॥

अस्मादिदमवगम्यते यत्कस्मिंश्चिन्मण्डले भ्रमद्द्रव्यं स्वजडताविरुद्धबलाधीनमभवति । उदाहरणे । यदि दूरे कश्चन मनुजः स्वहस्तं भ्रामयन् तत्परितः कन्दुकश्च भ्राम्यन् दृश्येत तदा दूरत्वादिकारणात् तद्धस्तकन्दुकयोर्मध्ये स्थितायां रज्ज्वामदृश्यायामपि तच्च रज्ज्ववश्यभावो ऽनुमीयते । तद्वच्चन्द्रस्यान्यग्रहाणाञ्च वृत्तभ्रमणे जाड्यानुकूलसरलगमनप्रतिबन्धकं किञ्चन बलान्तरमनुमीयते एकेनैव बलेनासरलगमनासम्भवात् ॥

अथैकस्मिन्नेव द्रव्ये युगपत्प्रयुक्तानां द्विचादिबलानां कार्य्याणि वर्ण्यन्ते ॥

एकस्मादेव बलादुत्पन्नं गमनं सर्वदा सरलरेखा-

यामेव भवतीत्युक्तं प्राक् । अथ पूर्वबलदिश्येव यद्य-
परं बलं संयुज्येत तदा गमनं शीघ्रतरमुत्पद्येत यथा
यदा गङ्गाप्रवाहे वहन्तीं नावं प्रवाहानुलोमगतिर्वा-
युर्हन्ति तदा सा नौरधिकं व्रजति । पूर्वबलविरुद्ध-
दिशि तदलेन सममन्यद्बलं संयुज्येत चेत्तर्हि गमनं न-
श्येत् यथा यदा समबलौ वृषभौ मिथः शिरः संयो-
गं कृत्वा समेन बलेन यत्नं कुरुतः तदा उभावपि
न परावर्त्तेते । विरुद्धदिशि तद्बलाद्यूनाधिकमन्यद्बलं
संयुज्येत चेत्तर्हि तद्बलद्वयभेदकृतशेषेण अधिकबल-
दिशि गमनमुत्पद्येत यथा यदा नौरनुकूलवायुबलेन
गङ्गाप्रवाहविलोमदिशि गच्छति तदा प्रवाहवायुबल-
भेदेनाधिकबलदिशि तद्गमनं भवति । एतत्स्पष्ट-
तरम् ॥

गमनकारणयोर्दिशौ यदि न समाने
नच विरुद्धे तदा गमनन्तद्दिशोर्मध्ये
भवेत् ॥ ४९ ॥

यथा नदीप्रवाहचेपणिभ्यां नौर्मध्यदिशि गच्छति । अत एव पारे इष्टघट्टे नौप्रापनार्थं नाविकः स्वीयनदी-प्रवाहयोर्बले विचिक्ष्यार्वाक्तीरात्तत्स्थानान्नावं मोच-यति यत्सम्मुखदिशः प्रवाहदिशश्च मध्ये इष्टघट्टस्य दिक् वर्त्तते ॥

यच्च गतेर्द्वौ हेतू भवतो ययोरेकेन सरल-रेखायाङ्गमनमभवेदपरेणच सदा कञ्चन निर्दिष्टबिन्दुप्रतिः तच्च चक्राकारभ्रमणमु-त्पद्यते ॥ ५० ॥

यथा भिन्दपाले हस्तेन भ्रामिते तदस्थः पाषाणो दूरमपसर्तुमिच्छुरपि हस्ताकृष्टा चक्राकारमार्गे ग-च्छति । तच्च यदि भिन्दपालः शीघ्रभ्रमणकाले भग्नो हस्ताच्युतो वा स्यात्तदा तत्स्थः पाषाण एकेनैव बलेन प्रचोदितो हस्तेन प्रक्षिप्त इव गच्छेत् ॥

एवं तैलिकयन्त्रे ऽपि वृषभः प्रचोदितः स्वयं सरल-

मार्गे जिगमिषन्नपि कण्ठबद्धतिर्यक्काष्ठावरोधेन चक्राकारमार्गे मध्यकाष्ठम्परितो भ्रमति । यदा स कण्ठबद्धकाष्ठादिमुक्तो भवेत्तदा प्रेरयितुः सकाशात् पलायन् गच्छेत् यतस्तच्च चक्राकारगमनहित्वोर्ध्वमधो आदिमोऽयमपि अभूत् ॥

अथ तद्बलसंज्ञा उच्यन्ते ॥

येनाकृष्टिबलेन तत्केन्द्ररूपनिर्दिष्टबिन्दुमिमुखमाकृष्यते तत्केन्द्राकृष्टिबलसंज्ञं स्यादथच येन बलेन तद्बिन्दोः दूरं सरलरेखायामपसरणशीलं स्यात् तत्केन्द्रोत्सृतिबलसंज्ञं स्यात् केन्द्राकृष्टिकेन्द्रोत्सृतिबलद्वयं केन्द्रसम्बन्धिबलसंज्ञं स्यात् ॥ ५१ ॥

केन्द्रोत्सृतिकार्योदाहरणानि उच्यन्ते ॥

तिर्यग्भ्राम्यमाणेषु कुलालचक्रादिषु स्थिताः पदार्था दूरमपसरन्ति ॥

पेषणयन्त्रे क्षिप्तं धान्यं तदुपरितनशिलया भ्राम्यमाणं सत् तन्मध्यात्तावद्दूरतो ऽपसरति यावद्बहिः पतेत् ॥

जलपूर्णघटस्य ग्रीवां रज्ज्वा बद्ध्वा ऊर्ध्वाधरं घूर्णयेत्तदा केन्द्रोत्सृतिबलेन तज्जलं न पतेत् ॥

कश्चन मनुजो ऽश्वो वा धावन् यदा ऽतिशैघ्र्येण निजगमनदिग्भिन्नां दिशं गच्छति स्वपातकस्य केन्द्रोत्सृष्टिबलस्य प्रतीकाराय स स्वबुद्ध्यैव तद्भिन्नदिशि नम्रो भवति । अचेतनशकटस्यतु झटिति गमनादिन्यैपरीत्ये स बहुधा परिवर्त्तते ॥

अतिकोमलमृत्पिण्डं कुलालचक्रमध्ये स्थापयित्वा तदतितूर्णं घूर्णयेत्तदा स पिण्डः केन्द्रोत्सृतिबलेन प्रसरिष्यति । एवं मृत्पिण्डवत् स्वाच्चम्परितो ऽतिजवेन भ्रमन्ती पृथ्वी निरक्षदेशे विस्तृताभूत् येन निरक्षभूव्यासस्तदक्षमपेक्ष्य किञ्चित्सान्तरैर्दशकोशैरधिको जातः । निरक्षदेशे तदाधिक्यवर्त्तनात्पृथ्वीचन्द्रसूर्या-

णामन्योन्याकृष्टिफलं किञ्चिद्विकृतमभूत् । अतो ऽयनचलनाद्या विकारा उत्पद्यन्ते यथाग्रे वक्ष्यन्ते ॥

यस्तुल्यकालांशयोस्तुल्यप्रदेशावतिक्रामति तस्य गमनं समानमस्तीत्युच्यते गमनमसमानमपि सम्भवति । तच्च सूत्रम् ॥

विषमं गमनं द्विविधम्भवति अपचीयमाणं वर्द्धमानञ्चेति ॥ ५२ ॥

यदा पूर्वबलविरोधि बलं सर्वदा प्रतिबन्धकं भूत्वा क्रमशः शैघ्र्यं न्यूनीकरोति तदा तद्गमनं अपचीयमाणं संज्ञं स्यात् । यथाच । उत्क्षिप्तपाषाणस्य गमनम्पृथिव्याकर्षणहेतोः क्रमेण मन्दतरम्भूत्वा विनश्यति । विनष्टे तस्मिन् पाषाणो ऽधो गन्तुमारभते । तचाधोगमनप्रकार ऊर्ध्वगमनप्रकारेण विरुद्धो ऽस्तीति तच्च वर्द्धमानं गमनं ज्ञेयं यतश्च तत्पाषाणः केनचित्कालेन किञ्चित्प्रदेशं गत्वा काञ्चन शीघ्रतां प्राप्य तेनैव कालेन तावन्तमेव प्रदेशं गच्छेत् जडत्वात् पुनः पृथिव्याकर्षणतस्तद्गमन-

क्रमेण शीघ्रतरमभवेत् । यतो यदा पाषाणः पतति तदा पतनकाले कञ्चन वेगं प्राप्तः सन् बलान्तरसंयोगाभावे स्वजडत्वात् समानकालखण्डेषु समानप्रदेशानतिक्रामेत् परन्तु तत्रानवरतं भूम्याकर्षणयोगो भवति अतस्तद्वेग उत्तरोत्तरं वर्द्धते ॥

यदा कश्चन बालः स्वहस्तात्कन्दुकं भूमौ पातयति तदा सो ऽव्यवहितोत्तरकाले तं कन्दुकं पुनः करेण धर्त्तुं शक्नोति परन्तु यदि तद्ग्रहणे किञ्चिद्विलम्बः स्यात्तर्ह्यनन्तरं हस्तस्य कन्दुकानुसरणं वृथा भवेत् ॥

उन्नताया वृक्षशाखायाः सकाशात्पतद्विल्वफलं किञ्चित्कालं नेत्रेण स्फुटं गोलरूपे द्रष्टुं शक्यते । तेनैव तदवरोहणवृद्धिक्रमो ऽपि ज्ञातुं शक्यते किन्तु तदनन्तरं अन्तिमकाले तत्फलस्य पतनशैघ्र्यात् केवलं रेखेव भासते ॥

वृहद्वृक्षाण्डात्किञ्चिद्वृद्वव्ये पातिते तत्पतत्यवाङ्नाकार उपरितनप्रदेशादधोभागे स्वावयववेगाधिक्यानुसा-

रंण उत्तरोत्तरं तनुर्भवति । यथा अनत्युच्चप्रदेशादपि गुडपाके पातिते स पाचान्निःसरणकाले स्थूलाकारो मन्दगामी भवति । ततः तलप्रापनात्प्रागेव स तन्तुरूपो जायते परन्तु स स्वसूच्मीभवनानुसारेण शीघ्रं गच्छन् विलच्चणशैघ्र्येण अधरपात्रं पूरयति ॥

अथामुकं द्रव्यमपेक्ष्यामुकस्य शीघ्रम्पतनं वायोः प्रतिबन्धादेव भवति । लेखनपत्रं मन्दं पतति किन्तु तदेव गुटिकीकृतं सच्छीघ्रम्पतति । सुवर्णमत्यन्तं गुर्वस्ति किन्तु सूच्मपत्रीकृतन्तद्वायौ वहति इव ॥

मुद्रापरिमितलेखनपत्रं मुद्रोपरि स्थापयित्वा पातयेत्तदा तत्पत्रं मुद्रया सममुवमागच्छति यतो मुद्राया अधःस्थित्या स्थानान्तर्गतो वायुः पत्रपतने प्रतिरोधको न भवति ॥

यस्मिन्पात्रे यन्त्रेण वाय्वभावो विहितस्तच्च मुद्रापत्त्री समानशीघ्रतयाधो यातः ॥

हस्तात्तिर्यक् प्रक्षिप्तः पाषाणः क्रमेणाधो गच्छति पृथिव्याकृष्टेः । यद्याकर्षणजा गतिः सरित्प्रवाहजगतिरिव समाना स्यात्तर्हि पाषाण उपरिलिखितनौरिव सरलरेखायामेवेयात् । परं आकृष्टपाषाणाधोगतेर्वर्द्धमानत्वात्तिर्यक्प्रक्षिप्तः पाषाणः प्रतिक्षणभिन्नदिशङ्गच्छतीति तद्गमनं वक्ररेखायाम्भवति इति प्रसिद्धम् । तद्वक्ररेखाया आकृतिर्नलिकाया जलसेचनेनापि दृश्यते ॥

वर्द्धमाना क्षीयमाणा चेति द्विविधा ऽपि गतिरान्दोलके दृश्यते । तच्च सूत्रम् ॥

अवलम्बितं यत्किञ्चिदपि द्रव्यं अग्रतः पृष्ठतश्च स्खलितान्दोलने युज्यते
यत्तदान्दोलकसंज्ञं स्यात् ॥ ५३ ॥

स्थिरस्थानाद्यष्ट्या ऽवलम्बितो गोलकः सामान्यान्दोलको भवति ॥

सूचेणावलम्बितात्पाषाणादनेकविधा आन्दोलकधर्मा लक्ष्यन्ते। इदानीमान्दोलकस्य धर्मविशेष उच्यते ॥

प्रत्यान्दोलनस्य प्रदेशन्यूनाधिकत्वेऽपि कालः समानः ॥ ५४ ॥

एतद्दर्शनार्थं द्विपञ्चाशदङ्गुलात्मकसूचान्तावलम्बितात्पाषाणादिरान्दोलकविशेषः क्रियतां तस्यैकवारमान्दोलनं असुपादेनैव भवति तावति तदधिकं न्यूनं वा प्रदेशं गच्छतु ॥

एतद्गुणविशिष्टत्वादान्दोलकस्य स कालमापने उपयुज्यते। साधारणघटीयन्त्रं केवलमान्दोलक एव भवति यस्मिन्नान्दोलके आन्दोलनसंख्यागणनार्थं चक्राणि संयुज्यन्ते यच्च घर्षणप्रयुक्तगतिरोधस्य वातप्रतिबन्धस्यच दूरीकरणाय कश्चन भारः स्थितिस्थापक-

विशिष्टं द्रव्यं वा युक्तं क्रियते ॥ अथ सूचयति ॥

आन्दोलकसूचदैर्घ्यविशेषात्तदान्दोल-
नकालविशेषो भवति ॥ ५५ ॥

आन्दोलकसूचं ह्रस्वं चेदान्दोलनं अल्पकालेन भवति । दीर्घं चेद्बहुकालेन भवति ॥

कर्मप्रतिकर्मणी मिथस्तुल्ये
विरुद्धेच भवतः ॥ ५६ ॥

आकर्षणमुत्सारणं वान्तरेण द्रव्येषु चलनरूपं कर्म नोत्पद्यत इति सिद्धं । तथाच नहि द्रव्यान्तरसम्बन्धरहिते केवलद्रव्ये इदं सम्भवति किन्तु मिथः सम्बद्धेषु द्विचादिद्रव्येष्वेवेदं वर्त्तते । तेषुच द्वयोर्द्वयोर्मध्ये यद्यप्येकं स्वीयबहुत्वाद्द्रव्यान्तरसंयोगजबहुत्वाभावाद्वा ऽपरस्मान्मन्दगतिस्तथापि यथैकमपरमाकर्षत्युत्सारयति वा तथैवा ऽपरमपि तदाकर्षत्युत्सारयति वेति बोध्यम् ॥

यथा यदि कश्चन मनुज एकस्यां नावि स्थित्वा ऽपरां नावं तद्बद्धरज्जोराकर्षणेनाकर्षति तदा ते नावौ मिथः सामीप्यमामुतः । तत्र स यामाकर्षति सा तमायाति याच्चारूढः सा आकृष्टनावं गच्छति । अथ यदि तौ नावौ महत्त्वेन भारेणच मिथः समाने तर्हि उभावपि समानगत्यैव चलतः । यदिच विषमे तर्हि आकर्षके तयोर्नावोर्मध्ये यां कांचिदप्यारूढे ऽल्पैव नौराशु व्रजति ॥

शतघ्याख्यास्त्रविशेषाद्यदा गोलको निःसरति तदा गत्युत्पादकबलं यावद्गोले वर्त्तते नहि तावतो न्यूनेन बलेन शतघ्नी पश्चात्सरति किन्तु शतघ्यां वर्त्तमानस्य गत्युत्पादकबलस्य महापिण्डे विस्तृतीभवना ज्जतिरल्पा उत्पद्यते तूर्णं नश्यतिच ॥

यस्य द्रव्यस्य द्रव्यान्तर आघातो जायते तस्मिन् तद्द्रव्यान्तरस्यापि प्रत्याघातो जायते । एतावाघातप्रत्या-

घातौ समानबलौ मिथो विरुद्धौच भवतः । स्थितिस्थापकविशिष्टद्रव्येषु इदं दृश्यते । सरलमार्गे चलन् कन्दुको यदि लम्बरूपेण भित्तौ पतेत्तदा स तस्मिन्नेव मार्गे परावृत्तो भवति । अथ यदि गमनमार्गे भित्तौ लम्बरूपो नस्यात्तर्हि भित्तौ संयोगस्थानाकृतस्य लम्बस्यैकपार्श्वे यावतान्तरेण स गच्छेत्तावतैवान्तरेणापरपार्श्वे स परावृत्तो भवेत् । यथा । समचतुष्कोणगृहस्यैकभुजप्रान्तात्तत्सम्मुखभुजमध्यचिह्ने प्रक्षिप्तः कन्दुकः पूर्वभुजस्यापरप्रान्तङ्गच्छति । गमनागमनरेखयोर्लम्बेन सहोत्पन्नौ कोणौ सदा मिथः समानौ भवतः । इदं कोणद्वयसाम्यं उष्णतादेरपि धर्मः । अत्र सूत्रम् ॥

पतनपरावर्त्तनकोणौ मिथः
समानौ ॥ ५७ ॥

तत्र दृष्टान्ता अग्रे दर्शनीयाः ॥

द्रव्येषु दृश्याः सर्वा गतयः पृथग्भूतानां संयुक्तानां वा परमाणूनां जाड्ये व्यवहरती आकर्षणोत्सारणे विना नोत्पद्यन्त इति पूर्वमुक्तम् । अधुना तद्युक्त्याधारत एव पिण्डीभूतद्रव्येषु वर्त्तमानयोः स्थैर्यगमनयोर्विशेषा वक्ष्यन्ते ॥

अथ पिण्डीकार्याणि ॥

यस्मिन् द्रव्ये परमाणवः परस्परं तथा दृढमाकृष्टा भवन्ति यथा तस्यैकदेशे चालिते तत्सकलं द्रव्यं स्वावयवानां परस्परान्तरविकारमन्तरा चलितं भवति तत्पिण्डसंज्ञं स्यात् । एतद्धर्मफलमुच्यते ॥

पिण्डस्यैकदेशं चालयद्वलं सकल-
पिण्डं चालयति अथवा तमेकदेशं
पिण्डात्पृथक्करोति ॥ ५८ ॥

मृन्मयपात्रे तद्ग्रीवैकदेशं धृत्वा उत्थापिते इदमुपपद्यते यत्पात्रभारमपेक्ष्य तत्परमाणूनां संयोगो दृ-

ढतरो ऽस्तीति । परन्तु यदि पात्रं शीघ्रमुत्थाप्येत तदा तन्त्रीवैकदेश एव उत्तिष्ठति पात्रञ्चाधः पतति यतस्तदानीं तत्र जाड्यं भारश्च द्वे ऽपि परमाणुसंयोगविघाताय भवतः ॥

यदि सरला काष्ठादियष्टिः तुलादण्ड इव मध्यदेशे ऽवलम्बिता स्यात्तर्हि तस्य प्रान्तौ परस्परं तुलयतः । अथ तत्प्रान्तयोः तुल्यभारसंयुक्तयोः सतोरपि समतोलनं विकृतं न भवति । तादृशयष्टेर्मध्यदेशो गुरुत्वकेन्द्रवाच्यः । इदं गुरुत्वकेन्द्रं प्रतिद्रव्यं भवतीतीत्येतदर्थं सूचम् ॥

यस्य कस्यापि पदार्थस्य संयुक्तपदार्थसमूहस्य वा गुरुत्वकेन्द्रसंज्ञको बिन्दुरस्ति यम्परितः तदंशानां समतुलता ॥ ५९ ॥

तस्मिन् बिन्दौ साधारे सति पदार्थो न पतति ।

यदि स बिन्दुर्निराधारः स्यात्तर्हि यस्मिन् पार्श्वे तेन स्थीयते तस्मिन्नेव पार्श्वे तद्द्रव्यं पतति । यथा । समानस्य काष्टदण्डस्य गुरुत्वकेन्द्रं मध्य एव वर्त्तते अतस्तस्मिन् बिन्दौ अङ्गुल्यादिना अवलम्बिते दण्डः स्थिरो भवति अथाधारस्य यस्मिन् पार्श्वे स बिन्दुः स्यात् तस्मिन्नेव पार्श्वे स दण्डः पतेत् ॥

गुरुत्वकेन्द्राद्भूपृष्ठे यो लम्बः स गुरुत्वलम्बसंज्ञः स्यात् । पदार्थो भूपृष्ठे यावन्तं देशमभिव्याप्य वर्त्तते तद्देशाद्बहिस्तद्गुरुत्वलम्बो न पतेच्चेत्तद्द्रव्यं तिष्टेत् अन्यथा पतेत् ॥

यदा अल्पनौस्था जना उत्तिष्ठन्ति तदा तत्सकलस्य नाम नौसहिततदन्तर्वर्तिजनस्य गुरुत्वकेन्द्रमप्युत्तिष्ठति । अतस्तदाऽल्पतरेणापि नौस्थितिविपर्ययेण गुरुत्वलम्बो बहिः पतति । अनेन नौमज्जनप्रसङ्गे भयात्तदन्तर्वर्तिनो नोत्तिष्ठेयुः इति ज्ञायते ॥

गोलस्य गुरुत्वकेन्द्रं गोलकेन्द्र एव वर्त्तते । अतः

समानभूभागे यत्र कुत्रापि स्थितो गोलः स्थिरो भवति यतः तद्गुरुसंयोगबिन्दावेव तद्गुरुत्वलम्बः पतति । परं क्रमनिम्नभूभागे स्थापितस्य गोलस्य गुरुत्वलम्बो न कदाचन गोलभूसंयोगबिन्दौ पततीति स गोलोऽधो गच्छति ॥

नहि द्रव्यमात्रस्य गुरुत्वकेन्द्रं तद्द्रव्य एव वर्त्तते । कङ्कणादिपदार्थानां गुरुत्वकेन्द्रं तन्मध्यस्थाकाशे वर्त्तते । तज्ज्ञानप्रकारोऽयम् । कङ्कणपालौ कस्मिंश्चित्स्थाने सूचम्बद्ध्वा तेन सूचेण तत्कङ्कणं लम्बयित्वा तत्सूचदिशि तच्चक्रमध्ये एकं सूचम्बध्नीयात् ततः कङ्कणपालावन्यस्थाने एवमेवान्यत्सूचं बध्नीयात् तथाच सूचद्वयसंपातः कङ्कणस्य गुरुत्वमध्यभवति यतस्तस्मिन्नेव लम्बिते कङ्कणमवलम्बितभवति ॥

पूर्वोक्तपदार्थधर्मेभ्यो गतिधर्मेभ्यश्च मनुष्यक्लेशलाघवाय अत्युपकारकाणि यन्त्राणि निर्मातुं शक्यन्ते ॥

कुलालचक्रभ्रमिदर्शनेन वक्ष्यमाणप्रतिज्ञाया युक्तिः स्फुटमवगम्यते ॥

यस्मिन् कस्मिंश्चित्पिण्डे स्वाक्षम्परितश्चक्रवत्तुलादण्डवद्वा भ्रामिते तस्य सर्वेषामवयवानां केन्द्रादक्षाद्वा यथा दूरत्वं तथा तेषां गतिविशेषः ॥ ६० ॥

चक्रे तत्प्रान्ते केन्द्रपरिध्योर्मध्यभागेच समानावार्द्रमृत्पिण्डौ स्थापयित्वा भ्रामिते केन्द्रपरिधिमध्यभागस्थ मृत्पिण्डमपेक्ष्य प्रान्तस्थ मृत्पिण्डो द्विगुणं देशमतिक्रामति ॥

अस्मिन् विषये वक्ष्यमाणो ऽर्थो मनस्यवधार्यताम् ॥

असमवेगविशिष्टपदार्थयोः समतोलनं सम्भवति यदि तौ किञ्चित्कठिनद्रव्ये तथा सम्बद्धौ स्यातां यथा चलनकाले अल्पतरप-

दार्थस्य गमनं महत्तरस्य भारप्रमाणाधि-
क्यानुसारेण अधिकं स्यात् ॥ ६१ ॥

एष एव सिद्धान्तः सकलयन्त्रनिर्मितिशास्त्रस्य मूलं भवति । अनेनैवोत्तोलनदण्डादीनि यन्त्राणि निर्मितानि भवन्ति यद्वारा शिल्पी यद्यद्बलं जगति प्राप्नोति तदिष्टकार्ये योजयितुं शक्नोति ॥

तच्चोत्तोलनदण्डाख्यं धातुकाष्ठादिनिर्मितं समानस्थौल्यविशिष्टमस्ति ॥

यद्युत्तोलनदण्डमध्यं आधारे स्यात्तर्हि तस्य द्वौ भुजौ समानौ स्याताम् ॥

अथ तद्भुजाग्रयोः समानगुरुत्वपदार्थाभ्यां संयुक्तयोरपि भुजद्वयसाम्याविघातः स्यात् । अनयैव युक्त्या व्यवहारे पदार्थगुरुत्वमापनार्थं तुलायन्त्रमकारि ॥

यद्युत्तोलनदण्डमध्यमाधारे न स्यात् किन्तु दण्डतृतीयांशचिह्नमाधारे स्यात्तर्हि यस्मिन्पार्श्वे दण्डस्य द्वौ

तृतीयांशौ वर्त्तेते तच गुरुत्वकेन्द्रं स्यात्तदा दीर्घभुजगुरुत्वमानं ह्रस्वभुजगुरुत्वमानद्वयेन तुल्यबलन्दृश्यते ॥

अतो यस्य तुलायन्चदण्डस्य भुजौ विषमौ स्यातां तत्क्रयविक्रयकाले छलार्थमुपयुज्येतेति स्पष्टम् ॥

यदि दण्डस्य चतुर्थांशचिह्नमाधारे स्यात्तर्हि दीर्घभुजगुरुत्वमानं ह्रस्वभुजगुरुत्वमानचतुष्कादिना तुल्यबलं स्यात् अपिच यदि दीर्घभुजगुरुत्वङ्किञ्चिदधिकं स्यात् तर्हि तत् ह्रस्वभुजे स्थितमन्यद् महद्गुरु उत्थापयेत् । अतो यदतिगुरु नानेकजनहस्तैरुत्थापयितुं शक्यते तदुत्तोलनदण्डोपायेन एकोऽपि मनुज उत्थापयितुं शक्नोति ॥

यावता कालेन ह्रस्वभुजस्थन्द्रव्यम् अल्पदेशमतिक्रामति तावतैव दीर्घभुजस्थम्बलं महाप्रदेशमतिक्रामति इति प्रत्यक्षम् । यन्त्रमाचे फलार्थं यथा यथा बलाल्पत्वन्तथा तथा कालाधिक्यम्बोध्यम् । नचैतावता यन्त्रमकिञ्चित्करमस्तीत्यनुमेयं यतः यत्कार्यं शरीरबल-

सहस्रेणापि असम्भाव्यन्तच्चेत्कालाधिक्येन सम्पद्येत तर्हि स महालाभो ज्ञेयः ॥

यच्च सरित्प्रवाहजं वातप्रवाहजं वा तप्ततोयवाष्पविस्तृतिजं वा बलङ्गमने हेतुर्भूत्वोपतिष्ठेत तच्च मनुष्यस्तद्बलं यन्त्रोपायेन वशीकृत्य तेन स्वसेवकवत् कर्म कारयितुङ्कल्पते । इदं यन्त्राणामधिकम्फलं ज्ञेयम् ॥

इति अद्रवद्रव्यधर्माः ॥

अथ जलादिद्रवद्रव्याणां धर्मा उच्यन्ते ॥

द्रवपदार्था निजकणानां सङ्घट्टनाल्पत्वात् न पर्वतवत् राशीभवन्ति किन्तु गुरुत्वाकर्षणवशात् पतन्ति । एतद्धर्मकथनार्थं सूत्रम् ॥

द्रवपदार्था सदा समानपृष्ठा
भवितुमर्हन्ति ॥ ९२ ॥

तत्कणानां गुरुत्वप्रयुक्तमधःपतनं निरपेक्षमस्तीति सर्वतस्तेषां मिथःपीडनम्भवति । ऊर्ध्वभागे यत्ते-

षाम्पीडनं तत् गुरुत्वविरुद्धं नास्ति किन्तु अधःपीडन-प्रयुक्तन्तत् ॥

यथा । यदा नालविशिष्टे पात्रे जलमुच्छिप्यते तदा किञ्चिज्जलं नालान्तरमारुह्य प्रांशुत्वेन पात्रस्थतोयसम-मवति पात्रतले स्थिता जलकणा उपरिस्थितजलकणैः पीडितास्सन्तो यत्र निःसरणमार्गः स्यात् तेन गच्छन्ति इह निःसरणमार्गो नाल एव प्राप्यते तैः अतस्तैस्तत्र गम्यते ॥

एवं जलधर्मं ज्ञात्वा समीपपर्वतकन्दरे जलाशयं च विलोक्य दीर्घं लोहनालं तत्र संयोज्य तद्वारा तज्जलं स्वनगरे अत्युच्छ्रितगृहाणामुपरिभागमपि नेतुं शक्यते । युरोपाख्यदेशवर्तिनगरेषु अयं महोपकारको जलप्राप-णोपायः क्रियते । अत्र तज्जलाशयस्थानेन नगरस्था-नादवश्यं उच्छ्रितेन भवितव्यं यतो मूलस्थानादुच्च-तरस्थाने नालद्वारा जलं न गच्छति यथा नालविशि-ष्टपात्रे दृश्यते ॥

अथ यदि पात्रस्थितजले अतिसूक्ष्मो नालः स्थाप्येत तदा तन्नालान्तर्गततोयम् उच्छ्रितत्वेन पात्रस्थतोयाद्-धिकं भवति नालपार्श्वानां आकर्षणात् । एवं दीप-वर्तिस्थातिसूक्ष्मनालद्वारा तैलं ऊर्ध्वं गच्छति अपिच वृक्षाणामतिसूक्ष्मनालैः जलमुपरि गच्छति ॥

अथ जलस्य जातीयगुरुत्वमापकत्वमुच्यते ॥

द्रव्याणां जातीयगुरुत्वस्य निर्णयाय जलं मापकं क्रियते ॥ ६३ ॥

जातीयगुरुत्वं सदा सापेक्षं भवति यथा लोहम-पेक्ष्य कर्करो जात्या लघुरस्ति किन्तु काष्ठमपेक्ष्य गु-रुर्भवति ॥

तच्च गुरुत्वमेवं निर्णीयते । पदार्थस्य सामान्यरूपेण गुरुत्वं विज्ञाय पश्चात् तज्जले स्थापयित्वैतद्गुरुत्वन्यून-ता निश्चेतव्या तदा गणितेन तस्य जातीयगुरुत्वं घटति ज्ञायते ॥

यथा। किञ्चित्सुवर्णखण्डमेकोनविंशतिपलमितमस्तीति ज्ञात्वा जले स्थितं तत्खण्डमष्टादशपलमितमभवति इति जानीयात्। ततस्तत्खण्डदेशे स्थितं जलम्पलमितं स्यात् इत्यनुमाय सुवर्णस्य जातीयगुरुत्वं जलगुरुत्वमपेक्ष्य एकोनविंशतिगुणं स्यादिति बोधयेत् ॥

यस्य पदार्थस्य जातीयगुरुत्वं ज्ञातव्यं स जले क्षेप्यः तदा यदि यावत्स जले मग्नस्तत्रैव तिष्ठेत् नाधो गच्छेत् तदा तस्य जातीयगुरुत्वं जलगुरुत्वेन तुल्यं ज्ञेयं यतो यस्य जलांशस्य स्थाने स पदार्थः स्थितः स जलांशो यावता बलेन पूर्वमवलम्बितस्तावतैव बलेन तत्तुल्यगुरुत्व एव पदार्थोऽप्यवलम्बितःस्यात् ॥

यः कोऽपि पदार्थो जले प्रक्षिप्तः सन् स्वगुरुत्वपरिमितजलं अन्यत्र कृत्वा स तत्र तिष्ठति परं यदि तन्मग्नं तद्गुरुत्वमितजलमहत्त्वादधिकं स्यात्। यथा। [illegible]ण्डः जले क्षिप्तः सन् मज्जेदेव यतस्तन्महत्त्वं स्व-

गुरुत्वमितजलमहत्त्वादूनं भवति परं स एव घटीकृतः तरति यतः स्वगुरुत्वमितमेव जलमन्यच्चकरोति स्वगुरुत्वमितजलमपेक्ष्य स्वमहत्त्वस्याधिक्यात् ॥

एवं नौः स्वभारानुसारेण जले किञ्चिन्मज्जति। तथा लोहनिर्मिता नावोऽपि तरन्ति। गङ्गायां या बाष्पीयनावो दृश्यन्ते ता लोहनिर्मिता एव सन्ति ॥

यस्य पदार्थस्य जातीयगुरुत्वं जलगुरुत्वाद्यूनं स्यात् तस्य जले मज्जनाभावात्तज्जातीयगुरुत्वं कथमवगन्तव्यमित्येतदर्थन्तस्मिन् लघुपदार्थे ऽवगतजातीयगुरुत्वो गुरुपदार्थस्तथा संयोज्यो यथा स लघुपदार्थो जले मज्जेत् ॥

जलादीनां स्थितिस्थापकोऽत्यल्पोऽस्ति। द्रवीभूतानां साधारणवाय्वादीनाम् महान्विद्यते। अथ वाय्वादिधर्मकथनमारेप्सुः सूचयति ॥

जलादिकात् वाय्वादिकस्य मुख्यो
विशेषः स्वस्थितिस्थापकः ॥ ६४ ॥

स्वस्थितिस्थापक इति । अतिबलेन पीडने वाय्वं-शस्य परिमाणमत्यल्पं भवति तत्पीडनस्थापसरणमाचेतु स वाय्वंशो झटिति यथापूर्वं विस्तृतो भवति ॥

स्थितिस्थापकवत्त्वाद्वायुः सर्वतः पीडयति ॥

अथ वायुजलयोस्समानो धर्म उच्यते ॥

वायुर्गुरुरस्ति ॥ ६५ ॥

अत्र प्रमाणान्युच्यन्ते ॥

वायोर्गुरुत्वादेव द्रवरूपा पदार्था नलद्वारा मुखेन आकृष्टुं शक्याः । यथा । नलस्यैकमग्रं जलान्तःकृत्वा द्वितीयं वक्त्रे धृत्वा उरःस्थानं विस्तारयेत् तदा तत्स्थानं विशालं भवति तच्चत्यो वायुश्च स्थितिस्थापकविशिष्टत्वाद्विस्तृतो भूत्वा लघुर्भवति अतो यावता बलेन जलं पीडितमभवति न तावता नालाग्रस्थितमिति तज्जलम्बहिःपीडनेन नालान्तः उपरिगच्छति ॥

उपयुक्तयन्त्रेण पात्रान्तर्गतं वायुं निष्काश्य तद्वायुरि-

क्तपात्रस्य गुरुत्वं निर्णीय पुनर्वायुपूर्णस्य तत्पात्रस्य गुरुत्वं निश्चीयते तथाच तद्गुरुत्वयोर्भेदात्तत्पात्रमितवायोर्गुरुत्वं ज्ञायते ॥

वायोर्जातीयगुरुत्वं जलगुरुत्वस्य अष्टशततमांशमितं भवति यतो यत्पात्रस्य वायुपूर्णस्य गुरुत्वं तस्यैव वातरिक्तस्य गुरुत्वात् माषेणाधिकं तस्मिन्पात्रे अष्टशतमाषमितं जलन्तिष्ठतीति प्रत्यक्षम् ॥

भूमेरूर्ध्वं द्वाविंशतिक्रोशपर्यन्तं सामान्यवायुः वर्त्तते इत्यनेकैर्हेतुभिरनुमीयते । वायोरुपरितनभागैरधःस्थिता भागाः पीडिता अतस्ते घनाःसन्ति उपरितनाश्च शिथिलीभवन्ति । अत्युच्छ्रितपर्वतशिखरे वायोः शैथिल्यात् निःश्वासकरणं दुर्घटम्भवति ॥

वातगुरुत्वमापकसंज्ञकयन्त्रेण पर्वतस्योच्छ्रायोऽवगन्तुं शक्यते ॥

अथ तद्यन्त्रनिर्माणविधिः । द्विहस्ताधिकदैर्घ्यविशिष्टं एकमुखङ्काचनालम्पारदेन पूरयित्वा तन्मुखमङ्गुल्या

कृत्वा तलमुपरि विधाय पाचान्तर्गतपारदे स्थापयित्वा अङ्गुलीन्निष्कासयेत् तदा नालवर्तिपारदः किञ्चिदधो यास्यति नालतले किञ्चित्स्थानं रिक्तमविष्यति यच्च वायुर्गन्तुं न समर्थः पाचस्थपारदनिवारणात् । अतस्तत्स्थानस्य रिक्तत्वान्नहि नालवर्ति पारदः सामान्यवायुना पीडितो भवति अतो नलस्थः पारदः सामान्यवायुपीडितेन पाचस्थपारदेन अवलम्बितो वर्तते अतो यच्च यदाच वायोर्गुरुत्वमधिकं स्यात् तच्च तदाच नालवर्तिपारदस्योच्छ्रता अधिका दृश्यते ॥

सामान्यतस्तस्योच्चता एकोनचत्वारिंशदङ्गुलपरिमिता भवति । यदि तद्यन्त्रम्पर्वतशिखरेवा उच्चगृहोपरिभागे वा नीयते तदा उपरितनवायोः शिथिलत्वात् तद्गुरुत्वपीडनस्याल्पत्वात् नालवर्तिपारदोऽधोगच्छति । एवमनेकवारं परीक्ष्य नालवर्तिपारदस्याधरीभवनज्ञानेन पर्वतोत्सेधस्य ज्ञानम्भवेदिति निश्चित्याऽधुना तत्कर्मणि तद्यन्त्रं उपयोजितम् ॥

स नालस्थपारदो झञ्झानिलागमनात्पूर्वमपि किं-

चिद्धो गच्छति अत इदं भक्ष्याभावातागमज्ञापकं यन्नम्
महासागरगन्तृनाविकानामत्युपकारकम्भवति ॥

अथ यावता वातपीडनेन रस एकोनचत्वारिंशदङ्गु-
लमितदैर्घ्यविशिष्टोऽवलम्बितस्तावता यस्य जातीयगुरु-
त्वम्पारदगुरुत्वादल्पम्भवति स अधिकदैर्घ्यविशिष्टोऽव-
लम्बितो भवेत् इत्यनुमीयतां । यथा । जलगुरुत्वम-
पेक्ष्य पारदगुरुत्वं सार्द्धत्रयोदशगुणम्भवति यावत्तत्सं-
ख्यया तन्नालवर्तिपारदोच्चलमितिर्हन्यते तावत द्वा-
विंशतिहस्ता लभ्यन्ते प्रत्यक्षेणापि तन्नाले जलस्योच्छ्रि-
तिस्तावत्येव दृश्यते ॥

अथ द्वयोरन्योन्यामिश्रणशीलयोः जलपारदादिद्र-
वपदार्थयोः तुल्यगुरुत्वांशप्रमाणज्ञानार्थं युक्तिरुच्यते ।
अङ्कुशाकारा वक्रा काचनली ऊर्ध्वाग्रा धार्या ततस्तन्न-
ल्यग्रयोस्तौ पदार्थौ तावत्तथा क्षेप्यौ यावद्यथा तन्नली-
मध्यभाग एव तयोः संयोगो वर्तेत तदा तयोः पदार्थ-
योः स्वव्याप्तदेशांशप्रमाणे विपर्ययेण तुल्यगुरुत्वांशमाने

न्नये । यथा । पानीयपारदयोः उक्तविधिना नल्यां चिप्तयोरेकाङ्गुलदेशवर्तिपारदः सार्द्धचयोदशांगुलदेशवर्तिपानीयेन मध्यचिह्न एवावलम्बते । अतः पानीयगुरुत्वमपेक्ष्य पारदगुरुत्वं सार्द्धचयोदशगुणमवति ॥

अथेदं यन्त्रमधराग्रं यदा धियते तदा तत्कुक्कुटनाडीयन्त्रमुच्यते इदमुपकारकं कुक्कुटनाडीयन्त्रभास्कराचार्यैः स्वशिरोमणिमिताक्षरायां यन्त्राध्याये वर्णितं । तथाहि । ताम्रादिधातुमयस्य शङ्कुरूपस्य वक्रीकृतस्य नलस्य जलपूर्णस्य एकमग्रं जलभाण्डे अन्यदग्रं वहिरधोमुखञ्चैकहेलया यदि विमुच्यते तदा भाण्डजलं सकलमपि नलेन वहिः स्रवति ॥

तद्यथा छिन्नकमलस्य कमलिनीनलस्य जलभृङ्गाण्डे चिप्तस्य जलपूर्णसुषिरस्य एकमग्रं भाण्डाद्वहिरधोमुखं द्रुतं यदि धियते तदा भाण्डजलं सकलमपि नलेन वहिर्याति । इदङ्कुक्कुटनाडीयंत्रं शिल्पिनां हरमेखलिनाञ्च प्रसिद्धमनेन बहवश्चमत्काराः सिध्यन्तीति ॥

एतद्यन्त्रकर्मापि वातगुरुत्वेनैवोपपद्यते । तद्यथा । भाण्डस्थतद्यन्त्राद्बान्तर्गतजलमपेक्ष्य बाह्याद्बान्तर्गतजलस्य गुरुतरत्वादाह्यभागस्थं जलम्बहिः पतितुमारभते । तेनापरार्द्धे नलो रिक्तो भवति अतस्तस्मिन्प्रदेशे सामान्यवायुगुरुत्वपीडितम् पात्रस्थज्जलमुत्तिष्ठत इति ॥

वायुः शब्दस्य मुख्यो वाहको भवति । अन्येऽपि पदार्थाः शब्दस्य वाहकाः सम्भवन्ति । अत्र सूत्रम् ॥

कर्णसंयुक्तवाय्वादौ अत्यन्तशैघ्र्येण स्पन्दनमुत्पद्यमानं शब्दप्रत्यक्षकारणम् ॥ ६६ ॥

वाय्वादाविति । जलस्याधोभागेऽपि जातो घण्टारवः श्रूयते ॥

एवमद्रवपदार्था अपि शब्दवाहका भवन्ति । यथा लोहदण्डाग्रं सूत्राभ्यान्बद्ध्वा तत्सूत्राग्रे कर्णसंयुक्तेच कृत्वा तल्लोहदण्ड अपरलोहखण्डेन हन्यताम् । तदा तत्सूत्रद्वारा यच्छब्दप्रत्यक्षं जायते तादृशं वायुद्वारा न भव-

ति । घण्टादिक्वणत्पदार्थस्य वादनेन तत्र अत्यन्तश्लेष्येण स्पन्दनमुत्पद्यते तत्स्पन्दनेन हंतो वायुरपि स्पन्दितो भूत्वा कर्णन्ताडयति तदा शब्दप्रत्यक्षं जायते ॥

वाय्वादिरहितपाचस्था घण्टा वादितापि शब्दं न करोति ॥ ६७ ॥

जलाशये पाषाणप्रक्षेपेण पतनस्थानमभितो ऽल्पस्तरङ्ग उत्पद्य क्रमशः प्रसरति । तस्य संलग्नतया परितोवर्तिनि जलेऽन्येऽपि तरङ्गास्तथैवोत्पद्यन्ते । एवं यथा ते तरङ्गाः क्रमशः प्रसरन्ति तद्वद्वायुवर्त्तिनोऽपि स्पन्दनोत्पन्नास्तरङ्गाः सर्वतः प्रसरन्ति ॥

दूरस्थो रजको वस्त्रेण प्रस्तरन्ताडयति तदा किञ्चित्कालेन आघातशब्दः श्रूयते । तेन इदमनुमीयते सूक्ष्मम् ॥

प्रतिप्राणपादं शब्दः ७६१ हस्तमितदेशं वायौ गच्छति ॥ ६८ ॥

शब्दगमनस्य शैघ्र्यं ज्ञात्वा शब्दहेतोर्दूरत्वं अनुमातुं शक्यते । यथा । यदि विद्युल्लतान्दृष्ट्वा चिंशत्प्राणपादान्तरेण मेघध्वनिः श्रूयेत तदा क्रोशचयाद्धिकदूरे मेघो नास्तीति अनुमीयते ॥

वायुतरङ्गपुनरागमनात्
प्रतिध्वनिर्जायते ॥ ६९ ॥

जलाशये उत्पन्नास्तरङ्गास्तीरं हत्वा परावर्तन्त इति दृश्यते । तद्वत् स्यन्दनोत्पन्ना वायुतरङ्गा अपि पर्वतगृहादिकं समानरूपं पदार्थं हत्वा पुनरायान्ति । तदा ज्ञातः शब्दः प्रतिध्वनिरुच्यते । अयं शब्दः पर्वतादागत इति कर्णेन बुध्यते यथा दर्पणे प्रतिबिम्बं दृष्ट्वा दर्पणपाश्चात्यभागे इदं वर्तत इति नेत्रेण बुध्यते ॥

तद्वत् यदि लम्बदिशि तरङ्गाणामाघातः स्यात्तदा गमनागमनरेखयोरैक्यं भवेत् नो चेन्न कथमन्यथा पतनपरावर्तनकोणयोः समत्वम् ॥

यथा द्रवाद्रवपदार्थानां आकर्षणजं गुरुत्वमस्ति तथा वायोरपि इति सिद्धं । परन्तु उत्सारणमुख्यकारणीभूताया उष्णताया गुरुत्वं नास्तीत्यनुमीयते मानाभावात यद्यपि तस्यामनेके वाय्वादिकस्य धर्मा सन्ति ॥

अथ गुरुत्वरहितपदार्थानां उष्णतादीनां विचारः ॥

उष्णताधर्मो धर्मिणः कदापि न
पृथक् दृश्यते नच तच गुरुत्वज-
डत्वयोः प्रमाणमस्ति ॥ ७० ॥

अयोगोलस्तप्तोऽपि गुरुतरो न भवति ॥

समीपवस्तूनि ह्युष्णतां सम-
तया विभजन्ति ॥ ७१ ॥

यथा । तप्तायोगोले जलपूर्णपात्रे प्रक्षिप्ते सति अयोगोलः शीतो भवति जलन्तु उष्णम्भवति ॥

यच्च उष्णताया न्यूनता तच्च शै-
त्यमिति व्यवहारः ॥ ७२ ॥

यथा । एकेन हिमालयप्रस्थादागतेन तथैकेन मध्यदेशाङ्गतेनचार्ङ्गपथसङ्गताभ्यामुभाभ्यां मिथो व्यतिसंवादे अहो अत्युष्णो ऽच वायुरहो अति शीतो ऽच वायुरिति न तच प्रत्यक्षं प्रामाणं तत्तत्पुरुषपूर्वानुभूतवायूष्णता न्यूनाधिकभावानुसार्यनुभवभेदेन ॥

किञ्च । यथाच जनभेदेनोष्णताशैत्यविसंवादस्तथा जनैक्ये ऽपि पूर्वानभूतोष्णशीतपदार्थधृतयोः करयोरनुष्णाशीतजले युगपत्प्रवेशेचैकेन करेणातिशीतमिदं जलमिति एकेनच करेणात्युष्णमिदं जलमितिचानुभवदर्शनाच्च न मनुष्यमात्रेणोष्णतामापनं किन्तूपायान्तरेणेति ज्ञेयम् ॥

उष्णतया पदार्था विस्तृता भवन्तीति य-

स्य पदार्थस्य विस्तरक्रमो मातुं शक्यते स
पदार्थ उष्णतामापकः सम्भवति ॥ ७३ ॥

अथ साधारणस्य उष्णतामापकस्य निर्माणविधिः । काचनलिकासहितकाचगोलं पारदेन जलादिना वा पूरयेत् तर्हि यदा उष्णताद्विर्भवेत्तदा पारदादिद्रव-पदार्थः क्रमेण विस्तृतो भूत्वा नलिकायामुपरि गत्वा उष्णताद्विक्रमं द्योतयति ॥

पदार्थविशेषेण तत्रोष्णताया
गमनशैघ्र्यविशेषः ॥ ७४ ॥

तद्यथा । अङ्गुलीभिर्धृतं ज्वलत्तृणं यावदङ्गुलिनिकटे न ज्वलेत्तावदङ्गुलीषु नोष्णताप्राप्तिर्भवेत् । धात्वादिषु त्वतिशीघ्रमेवोष्णता तद्द्वारा चलति । यथा । लोहसूचस्यैकस्मिन् भागे ऽङ्गुलीभिर्धृते ऽपरस्मिंश्चाग्नौ निवेशिते ऽत्यल्पेनैव कालेनाङ्गुलीषूष्णताप्राप्तिः ॥

शून्यमार्गद्वाराप्युष्णता
गन्तुं शक्नोति ॥ ७५ ॥

तच किरणरूपा उच्यन्ते ॥

तप्तायोगोलकात्सर्वतः सरलरेखाभिस्तेजो गच्छति । पतनपरावर्त्तनकोणयोः साम्यं धर्म उष्णताया अपि अतो यदा सरलरेखाभिस्समागता रविकिरणा मध्यनिम्ने दर्पणे पतन्ति तदा पतनपरावर्तनकोणयोः साम्यात् मध्यदिशि युक्तस्थले तावति दूरे विन्यस्तमन्नं पक्वमविष्यति ॥

अथ काष्ठादिकं घृष्टं उष्णं भवति । कौशेयघृष्टकाचनल्या और्णघृष्टलाक्षाया वा उष्णतया सह किञ्चिदन्यदप्याविर्भवति यत् तादृशी नली समीपस्थं लघुतृणं पत्रं वा आकृष्य मुञ्चति ॥

महत्याश्च तादृङ्नल्याः समीपे स्वाङ्गुल्यां नीतायामेकः स्फुलिङ्गस्ततो निःसरत्यल्पो ध्वनिश्च ततः श्रू-

यते । यदा वायुश्शुष्को भवति तदा विडालपृष्ठे हस्तस्य घर्षणेन प्रोक्तकार्यमनुभूयते ॥

यो ऽत्र हेतुः स एव मेघेभ्यो विद्युन्निसृत्य शब्दायत इत्यत्र भवतीति ज्ञानिभिर्मेघाद्विद्युतमासाद्यावगतम् ॥

अथ विद्युदप्युष्णतावत्सदा समानभावेन स्थातुं यतते ऽतो यस्मिन् मेघे ऽधिका विद्यत्स्यात्ततः सा समीपस्थमल्पविद्युद्विशिष्टं मेघं वृक्षं मन्दिरं वा सशब्दं हठात्प्रविशति ॥

अथ यत्र पदार्थे विद्युद्बाहुल्यं स्यात्ततो विद्युद् गर्जनमन्तरेण हठात्तीक्ष्णाग्रविशिष्टपदार्थान्तरं प्रविशति । अत एव कलिकत्तादिनगरस्था विद्युत्पातक्षतिनिरासाय गृहोच्छ्रायाधिकोच्छ्रायां तीक्ष्णाग्रां लोहयष्टिं स्वगृहे निखनन्ति ॥

यदा पदार्थानां रसायनसम्बन्धी विकारो भवति

तदापि तत्र विद्युत्कार्यं प्रादुर्भवति । तादृशी विद्युद् गाल्वानिसम्संज्ञिका यतः सा गाल्वानिसंज्ञकेनाविष्कृता ॥

वङ्गलण्डदेशे तया क्रोशशतान्तरे एकेन पलेन वृत्तं ज्ञापयितुं शक्यते । तस्याः समग्रसामग्री चेदिह भारतवर्षे भवेत्तर्हि किंचन वृत्तं कलिकत्ताख्यनगरादग्राख्यनगरे ज्ञापयित्वा ततो दिल्ल्याख्यपुर्यां ततश्च मुम्बय्याख्यराजधान्यां एकघटिकावकाशेन ज्ञापयितुं शक्येत ॥

तस्या एव विद्युतः साहाय्येन दूरस्थेऽपि भाण्डे स्थितो बारूदाख्यशीघ्रदाह्यपदार्थो ज्वलयितुं शक्यः । यदा काचन महानौर्नद्यां मज्जति येनान्यतरणिगतागतावरोधः स्यात्सा महानौस्तद्विद्युत्साहाय्येन ततो निष्कासयितुं शक्यते । एतदुपायद्वाराचापि देशे गङ्गायां निमग्ना नौकावृक्षादयो ऽव्यवहितपूर्वकाले निष्कासिताः ॥

तयैव कृतप्रवेशं लोहं लोहचुम्बको भवति ॥

प्रकाशोऽपि गुरुत्वरहितोऽस्ति । तं विना दृष्टिर्न भवति । अथ दर्शनानुशासनम् ॥

इह दर्शनानुशासने स्वप्रकाशपरप्रकाशपारदर्शकभेदात् पदार्थास्त्रिविधा ज्ञेयाः । सूर्यदीपादयः स्वप्रकाशाः । लोहादयः परप्रकाशाः । काचादयः पारदर्शकाः । अत्र प्रसङ्गे पारदर्शका मध्यस्थसंज्ञाः स्युः ॥

स्वप्रकाशपदार्थात्प्रकाशकिरणा निर्गत्य
सर्वतः सरलरेखाभिर्व्रजन्ति ॥ ७६ ॥

तत्र मार्गे यदि परप्रकाशः पदार्थः स्यात्तदा तेन प्रकाशावरोधात् तत्पृष्ठे तमो भवति । तत्र यदि भित्त्यादिः स्यात्तर्हि च्छाया उत्पद्यते ॥

प्रायश्च्छाया अत्यन्तकृष्णा न भवति यतो यत्र छाया जायते तत्र प्रायोऽन्यपदार्थपरावृत्तः प्रकाश आगच्छति यथा दीपद्वयेन घटस्य च्छायाद्वयमुत्पद्यते तत्रैकस्मिन्दीपे नष्टे एकैव च्छाया कृष्णतरा भवति कि-

न्तु न सा अत्यन्तकृष्णा यतो गृहभित्त्यादिसमीपपदार्थपराहत्तः प्रकाशस्तत्र गच्छति ॥

अथ यत्र स्वप्रकाशः पदार्थः परप्रकाशात्पृथुतरो वर्तते तत्र किरणमार्गस्य सरलत्वात् छाया क्रमेण न्यूनीभूयान्ते विनश्यति । एवं यदा कदाचित् सूर्यग्रहणे चन्द्रच्छाया भुवं नागच्छति तदा क्वचित् चन्द्रं परितो वलयाकारो रविर्दृश्यते ॥

यत्र स्वप्रकाशः परप्रकाशादल्पीभवति तत्र च्छाया दूरत्वानुसारेणोत्तरोत्तरं वर्द्धते यथा दीपकृता मनुष्यच्छाया कदाचिद्विंशतिहस्तपरिमाणा स्यात् ॥

प्रकाशो ऽतिशीघ्रं गच्छति ॥ ७७ ॥

सूर्यान्निर्गतः किरणो दण्डतृतीयांशकालेन भुवं एति । अतो यदा किरणो भुवमागच्छति ततः पूर्वमेव दण्डतृतीयांशकालेन रविः किरणनिर्गमकालिकं स्वस्थानं त्यजति । अथ प्राप्तकिरणदृश्येव दण्ड-

तृतीयांशेन अतिक्रान्ते स्थाने वयं रविं पश्यामः ॥

अथ प्रकाशकिरणगतिमितिः पूर्वं कथमवगतेति तदुच्यते । गुरोश्चत्वारश्चन्द्राः सन्तीति पूर्वमुक्तम् तेषाञ्च ग्रहणानि मुहुर्भवन्ति । तत्काला रविग्रहवद्गणितेन ज्ञातुं शक्याः । अथ यदा रविगुर्वोर्मध्ये भूर्वर्तते तदा गुरुः भूनिकटे तिष्ठति यदा च कुगुर्वोर्मध्ये रविरास्ते तदा गुरुः भूमेर्दूरे तिष्ठति । अथ गुरुसमीपवर्तनकाले सञ्जातानां ग्रहणानां दृग्गणितैक्यङ्कृत्वा तदनुसारतोऽन्यानि आगामिकालिकग्रहणानि ज्योतिर्विदो गणितेन निरणयन् । परन्तानि ग्रहणानि गुरुदूरवर्तनकाले दण्डतृतीयांशद्वयविलम्बेनापश्यन् । ततः दूरत्वात्किरणागमेऽयं विलम्बोऽभूदित्यनुमाय किरणगमनमानं गणितेनावागच्छन् । तद्यथा । भूमिसूर्ययोरन्तरं पञ्चचत्वारिंशन्नियुतक्रोशमितमस्तीति प्रसिद्धम् । अतो भूगुर्वोर्गुरुनिकटवर्तनकालभवात् अन्तरात्तद्दूरवर्तनकालिकमन्तरं नवतिनियुतक्रोशैरधिकं

स्यात् इति स्पष्टम् । अत एव प्रकाशकिरणो दण्ड-तृतीयांशद्वयेन नवतिनियुतक्रोशान् गच्छति एकेना-नुपादेनच लक्षक्रोशासन्नङ्गच्छतीति स्पष्टम् ॥

यदा प्रकाशकिरणाः परप्रकाशे पतन्ति
तदा ते प्रायः पराव्रजन्ति भित्तौ प्रच्छिन्नाः
स्थितिस्थापकविशिष्टा गोला इव ॥ ७८ ॥

अतोऽत्रापि पतनपरावर्तनकोणयोः साम्यमभवति । अन्धकारमये गृहे यदि अतिसूक्ष्मच्छिद्रेण आगतः सूर्यकिरणो दर्पणीदरे लम्बरूपः पतेत्तदा एक एव किरणो लक्ष्यते पतनपरावर्तनरेखयोरैक्यात् । पुनर्यदि दर्पणस्तिर्यक् क्रियते तदा तथा न भवेत् ॥

स्वप्रकाशपदार्थादागतैः किरणैः स पदार्थो दृश्यो भवति । अन्येतु परावृत्तः किरणैरेव दृश्या भवन्ति । दर्पणे किरणः पततीति पूर्वमुक्तं । तत्र स किरणो ऽस्माभिर्न दृश्यते किन्तु च्छिद्रदर्पणयोर्मध्यावकाशे रजो

बाहुल्यं वर्तते अतस्तद्रजसः परावृत्तः प्रकाशोऽस्माकं नेत्रयोर्लगति ॥

यदा प्रकाशकिरणः कञ्चित्पारदर्शकं त्यक्त्वा अन्यस्यापि पारदर्शकस्य मार्गेण गच्छेत् तदा किरणवक्रीभवनं जायेत ॥ ७९ ॥

अत एव यदा दण्ड ऊर्ध्वाधररूपो जले वर्तते तदा तस्य निमग्नोऽशो ऽल्पीभूतो दृश्यते । यदा तिर्यक् वर्तते तदा स जलपृष्ठस्थाने भग्नो दृश्यते । इदङ्किरणवक्रीभवनसंज्ञं स्यात् । एवं प्रकाशः कस्यापि पारदर्शकस्य मार्गेण गच्छेत् तदापि किरणवक्रीभवनं जायेत ॥

प्रकाशकिरणो वायुं त्यक्त्वा जलं विशतीति कल्प्यतां । तदा यदि स किरणो जलपृष्ठे लम्बरूपः पतेत् तदा वक्रो न भवति किन्तु यदि लम्बरूपो न स्यात्तदा स वक्रीभूय लम्बदिशि गच्छति ॥

पुनर्यदा किरणो घनविषयात् सूक्ष्मविषये गच्छति तदा पूर्वोक्तरीतिविपर्ययेण स लम्बाद्दूरे वक्रीभूय गच्छति ॥

एतत्प्रतीत्यर्थम् मृत्पात्रे मुद्रां संस्थाप्य तत्पात्रन्ता-दृशे स्थाने न्यसेत् यत्र सूर्यदीपादिकिरणैः मुद्रास-न्नाः पार्श्वांशाः प्रकाश्यन्ते किन्तु मुद्रा अदृष्टा स्यात् । ततस्तस्मिन्पात्रे मन्दं मन्दं जलं क्षिप्यतां । तदा ते किरणा लम्बदिशि वक्रीभूय तां मुद्राम्प्रकाशयेयुः ॥

अपिच पात्रे मुद्रां विन्यस्य तामवलोकयन् पश्चात्ता-वदपसरेत् यावत् सा मुद्रा पात्रपार्श्वेण तिरोहिता स्यात्तदा यदि कश्चन तत्पात्रे मन्दं मन्दं जलम्प्रक्षिपेत् तदा सा मुद्रा दृष्टा भवेत् । यतो ये किरणा मुद्रा-पराद्दत्ताः पूर्वं पात्रकण्ठमागम्य नेत्रस्योपरिभागे ज-ग्मुस्तेऽधुना लम्बात् दूरतः नेत्रे पतन्ति ॥

अत एव सरित्सरस्यादीनां यत्तलं लक्ष्यते तद्वास्त-वतलादुच्छ्रिततरम्भवति । तेन तरणविद्यायामकुशला

अज्ञानिनो बाला अत्र जलं गम्भीरं नास्तीति विचिन्त्य तत्र स्नानार्थङ्कृत्वा विनश्यन्ति ॥

सूर्यतारादीनाङ्किरणाः साधारणवायौ आगम्याधो वक्रीभवन्ति । तेन क्षितिजसमीपे यदा ग्रहादि खस्थं वर्तते तदा तत् वास्तवस्थानात् उच्चदेशे दृश्यते । नेत्रकिरणसंयोगकाले यस्या दिशो द्रव्यपरावृतः स किरण आयाति तस्यामेव दिशि तद्द्रव्यं वर्तत इति नेत्रेण बुध्यते ॥

यत्खस्थमूर्ध्वं स्वस्तिके वर्तते तस्य किरणा वक्रा न भवन्ति । क्षितिजस्थस्य वक्रीभवनम्परमं विद्यते । तत उन्नतस्य किरणवक्रीभवनन्यूनता स्यात् । अतः सूर्योदयसमये विम्बोर्ध्वभागकिरणवक्रीभवनमपेक्ष्याधोभागकिरणवक्रीभवनं अधिकम्भवति । अत एव यदा आर्द्रतादिहेतुभिः वायुर्घनोस्ति तदोदयकाले रविविम्बमण्डवत् दृश्यते ॥

अथ ज्यौतिषगणितविषये किरणवक्रीभवनभूतं सूर्यादिस्थानान्तरमवश्यमनुमेयं भवति । अतः कुजादूर्ध्वम् प्रत्यंशं वक्रीभवनफलं निश्चित्य ज्यौतिषसारण्यां लिखन्ति ॥

काचमयसमानशिलायां यः किरणो लम्बरूपो न पतति स पूर्वं काचप्रवेशकाले उक्तवत् लम्बदिशि वक्रीभूय ततो निर्गमकाले पुनर्लम्बाद्दूरे गच्छतीति इह तद्वक्रीभवनम् द्विविधमवति । अत्र किरणगतौ स्वल्पो विकारो भवति ॥

अथ गोलखण्डरूपे मध्योन्नतकाचे ये किरणाः पतन्ति तत्र तन्नोलकेन्द्रगामीकिरणो वक्रत्वन्नाप्नोति अन्येच प्रवेशकाले तदुत्तदिशि वक्रीभवन्ति निर्गमकालेच प्रोक्तकारणानुसारतः सर्वेऽग्रे एकस्मिन् विन्दौ समुद्यन्ति ॥

सूर्यकिरणानां तत्समुदयस्थले पटादिद्रव्याणि ज्वलन्ति ॥

अथ मध्योन्नतकाचद्वारा सूक्ष्मः पदार्थो महान्दृ-
श्यते ॥

अथ तद्धेतुभूतमुच्यते । नेत्राद्दूरे यः पदार्थो वर्तते सोऽल्पो दृश्यते यश्च निकटे स महान् दृश्यत इति प्रसिद्धम् । अथ नेत्राद्धस्ततृतीयांशमितदूरदेशे स्थितः पदार्थः स्वस्थनेत्रेणातिस्पष्टो दृश्यते । तदधिकसमीपे स्थितः ततो महानपि अस्पष्टो दृश्यते तत्तदूरे धृतपुस्तकमालोक्य एतत्प्रतीतिरुत्पाद्या ॥

अथास्पष्टत्वे हेतुरुच्यते नेत्राग्रभागे स्वच्छजलनिर्मितो मध्योन्नतकाचवत् नेत्रांशो वर्तते । तच्च स्वस्थे नेत्रे किरणवक्रत्वं तादृशमभवति येन हस्ततृतीयांशान्तरितप्रदेशादागताः किरणाः नेत्रान्तः स्थितचित्रपटे पूर्वोक्तरीत्या एकत्र समुद्यन्ति तेन दृष्टिस्पष्टता जायते ॥

दृङ्मनुष्यस्य नेत्रे प्रायस्तदंशजलं न्यूनमभवति तदा तत्कृतकिरणवक्रीभवनमपि न्यूनञ्जायते । अतो हस्ततृतीयांशान्तरितदेशेस्थितस्य ग्रन्थस्य वर्णाः दृङ्मनु-

जेन स्पष्टं नेक्ष्यंते हस्तमितदूरात्स्फुटतरमवलोक्यन्ते ॥

तत् हस्ततृतीयांशदूरात् स्फटमालोकयितुं काच-द्वयनिर्मितं अधिककिरणावक्रत्वकारकं यन्त्रं क्रियते ॥

अथ अत्यन्तकिरणावक्रत्वकारकमध्योन्नतकाचद्वारा नेत्रस्यातिनिकटेऽपि स्थितः सूक्ष्मः पदार्थः स्फुटमति-महान् दृश्यते अतस्तादृशः काचखण्डः सूक्ष्मदर्शक इ-त्युच्यते ॥

अथ सूक्ष्मदर्शकनिर्माणस्य सुगमोपायोऽयम् । अ-स्थूले ताम्रादिपात्रे सूक्ष्मं वृत्तच्छिद्रं क्रियताम् । तत्र स्थितो जलविन्दुर्गोलीभूय सूक्ष्मदर्शको भवति ॥

मध्यनिम्नकाचखण्डस्य धर्माः पूर्वोक्तविरुद्धा ज्ञेयाः । तद्वारा पदार्था अल्पतरा दृश्यन्ते ॥

कदाचित् कस्यचिद्बालकस्य चक्षुषि पूर्वोक्तस्वच्छज-लनिर्मितांशस्य जलाधिक्येन किरणवक्रत्वं तादृशमभवति येन किरणानां समागमो नेत्रस्य मध्ये भवति । तत्र किरणा एकीभूयाग्रे स्वस्वरेखायाङ्गत्वा पृथक् चित्रपत्रे

पतन्ति अतस्तच्च दृष्टिस्पष्टत्वं न भवति । स बालको ऽतिसमीपस्थानेच पदार्थान्स्पष्टम्पश्यति । पठनकाले नासिकाग्रभागे पुस्तकन्दधाति ॥

अथ तस्य हस्ततृतीयांशदूरात्स्पष्टतया आलोकनार्थं मध्यनिम्नकाचद्वयेन तादृशं यन्त्रं क्रियते यद्द्वारा विरुद्धवक्रत्वमापन्नाः किरणाः तस्य नेत्रे गच्छेयुः ॥

तस्य बालकस्य दृङ्नेत्रे यदि नेत्रवर्तिजलस्य न्यूनता स्यात् तदा स जातु यन्त्रं विनैव स्पष्टन्द्रक्ष्यति इति तस्य लाभः ॥

ये पदार्थाः वस्तुतः सूक्ष्मा न सन्ति किन्तु दूरत्वहेतोः सूक्ष्मा दृश्यन्ते तेषां स्पष्टत्वेन दिदृक्षा चेत् तर्हि तच्च दूरदर्शकयन्त्रम्प्रयोजयेत् ॥

एतद्यन्त्रस्य अनेके प्रकारा भवन्ति । तत्रैको वर्ण्यते । तथाहि । उपयुक्तनलिकाया अन्ते तादृशो विपुलदर्शकः काचखण्डः स्थाप्यते येन दूरस्थितपदार्थादागताः किरणाः वक्रीभवेयुः । अपिच किरणानामेकीभवन-

स्थानात्पूर्व नलिकाया अपरान्ते स्थापितेन मध्यनिम्न-काचखण्डेन तद्वक्रत्वस्य तादृशः प्रतिरोधः क्रियते येन दृष्टिस्पष्टत्वम् भवेत् । तथाच तेन स पदार्थो महाकारो दृश्यते आसन्न इव बुध्यतेच ॥

शुक्लः किरणो विचित्ररूप-
किरणनिर्मितो ऽस्ति ॥ ८० ॥

अस्य प्रमाणमुच्यते । काचमयं गोलरूपञ्जलपूर्णम्पात्रं स्वशिरोऽपेक्ष्योच्चतरे स्थाने विन्यस्य हस्तेन धृत्वाधा सूर्यपात्रयोर्मध्ये तिष्टेच्चेतर्हि ये यै विचित्रा वर्णा इन्द्रधनुषि दृश्यन्ते तान् सर्वान् तत्पात्रे पश्यति । ततः पात्रे उत्थापिते ऽधः कृते वा क्रमेण पीतहरितनीलादिरूपाणि दृश्यन्ते । अथ स्वच्छजलादेतद्रूपवैचित्र्यं कथमुत्पद्यत इत्येतदर्थमुच्यते शुक्लः किरणस्तद्विचित्ररूपकिरणनिर्मितोऽस्तीति ॥

परप्रकाशपदार्थाः परावृत्तैः किरणैरेव दृश्यन्त इति

पूर्वमुक्तम् । परं नहि सकलपदार्थेभ्यः सकलकिरणाः परावर्जन्ति । यस्मात् सर्वे परावर्जन्ति स एव शुक्लो दृश्यते । यस्मात्कोऽपि किरणो न परावर्जति स कृष्णो दृश्यते ॥

तेजसा सह तत्त्वा उष्णतापि परावर्जति प्रविशतिवा । अतः कृष्णवस्त्रमुष्णमवति शुक्लञ्च शीतम् । अपिच विपुलदर्शकाचखण्डकृष्णं वस्त्रं शीघ्रं दहति न तथा शुक्लम् ॥

यस्मात्पदार्थाद्रक्तकिरणा एव परावर्जन्ति स रक्तो दृश्यते यस्माच्च पीतकिरणाः स पीत इत्यादिरूपधर्मो बोध्यः ॥

अथ शुक्लकिरणवर्तिरक्तपीतनीलरूपाणां वक्रीभवनशीलं समानं नभवति । पीतमपेक्ष्य नीलस्य वक्रत्वं अधिकम्बोध्यं रक्तस्य च न्यूनम् ॥

एतत्प्रतीत्यर्थञ्चतुर्भुजाकृतिपार्श्वचयविशिष्टकाचखण्डमन्धकारमये गृहे तथा स्थाप्यं यथा तत्र सूक्ष्मच्छिद्रे-

णान्तः सूर्यकिरणः पतत् तदा तच्छिद्रागतो यः किरणः पूर्वभित्तौ शुक्ल एव दृष्टः स रक्तपीतनीलादिरूपयुक्तो दृश्यते । त्रिपार्श्वकाचखण्डकृता किरणवक्रगतिः पूर्वोक्तवक्रीभवनधर्मानुसारेण विपुलदर्शककृतेव वारद्वयं समानदिशि विद्यते परन्तु पार्श्वसमत्वात् न तथा किरणसमाहारो जायते ॥

यदि त्रिपार्श्वकाचेन भिन्ना विचित्ररूपकिरणा विपुलदर्शककाचे पतन्ति तदा पूर्वोक्तवक्रीभवनधर्मानुसारेण पुनस्ते एकीभूय शुक्लं स्वरूपम्प्रकटयन्ति एवम्प्रकारेण किरणस्य पृथक्करणम् पुनरेकीकरणञ्च कर्तुं शक्यते ॥

कुज्झटिकासमये रवेरागता रक्तरश्मयो नेत्रमागच्छन्ति । अन्येतु अधिकवक्रीभूतत्वात् नायान्तीति तत्काले रवी रक्तरूपो दृश्यते ॥

अथ यथा त्रिपार्श्वकाचेन जलपूर्णकाचपात्रेण वा शुक्लकिरणस्य विचित्ररूपाणि पृथक् भवन्ति तद्वर्षणकाले भानुभानवः पतद्बिन्दुसन्दोहे पतित्वा पृथग्भूत्वाच नेत्रमायान्ति। रक्तपीतनीलादिप्रत्यक्षं सूर्यनेत्रबिन्दुजातकोणपरिमाणाश्रितमिति पूर्वोक्तजलपूर्णकाचपात्रस्य परीक्षणेन सिद्धम् । अथ ये जलबिन्दवः रविनेत्राभ्यान्तुल्यकोणेषु वर्तन्ते ते वृत्तवृतिवर्तिन एव भवन्ति इति क्षेत्रगणितज्ञेन ज्ञायते अत इन्द्रचापाकारो वृत्त एवास्तीति ॥

जडवस्तूनां गतिर्बलकार्याणि तेजःप्रभृतीनां विविधानि प्रसरणानिच रेखानियमेन प्रदेशनियमेन चोत्पद्यन्ते तत्तत्रेखाप्रदेशयोर्धर्माणां ज्ञानं गत्यादिनियमज्ञाने सहकारि। एवं गतिबलप्रसरणानि कालाश्च रेखाप्रदेशादिपरिमाणेन परिच्छिन्नाः सन्तः संख्यायापि परिच्छेत्तुं योग्या यथान्यानि सर्ववस्तूनि

इत्यतः संख्यापरिमाणादिविचारस्योत्तरप्रकरणे कार्-
ष्यमाणत्वादस्मिन् प्रकरणे इहैव विरम्यत इति ॥

॥ इति द्वितीयाध्यायः समाप्तः ॥

A

SYNOPSIS OF SCIENCE;

FROM

THE STANDPOINT

OF

THE NYÁYA PHILOSOPHY.

SANSKRIT AND ENGLISH.

VOL. II.

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PREFACE.

In the Third Book of the Synopsis an attempt to establish a purely Hindú nomenclature for the science of Chemistry has been commenced. Mr. Mack, in the preface to his very careful treatise on Chemistry published in Bengálí and English at Serampore, in 1834, tells us that he was advised to discard all European terms in his Bengálí version, but that he could not persuade himself to adopt the advice. He retained therefore many of the European names, and adapted Sanskrit terminations to them. Several of these terminations have been adopted in the present essay, but the European names have been entirely discarded. As an educational instrument,—and it is in *this* capacity that we at present seek to employ it,—the science of Chemistry loses more than half its value when its compound terms do not tell their own meaning; and it is impossible that they should rightly tell their own meaning to one who is not familiar with the language from which they are derived. To an Englishman, unacquainted with the classical languages, the study of a work on Chemistry is very far from being such a mental exercise as it is to a classical scholar. The long compound names which exercise the reflection and excite the admiration or provoke the criticism of the latter, more frequently torture the memory and bewilder the understanding of the former. How entirely is the scientific beauty of the nomenclature thrown away upon the man who must look out Hydro-chlorate and Sesquioxide in his glossary in order to make sure which is which. It is all very well to teach long chemical names by rote to a youth who is to be em-

ployed as an apprentice in wielding a pestle. Him you perhaps do not seek to educate; you merely make a convenience of him; and if he does not practically mistake Corrosive Sublimate for Coloquintida in making up a prescription, why all is well. The case is otherwise where the aim is to educate and to instruct. Where Chemistry is to be efficiently employed for such a purpose, the learner must be conversant with Latin and Greek, or else the language of the science must be rendered into the language of the learner, as has been in a great measure done by the Germans for themselves.

The first question, in settling a chemical nomenclature, regards the naming of the Simple Bodies. The common metals, as well as sulphur and carbon, have names in most languages which there is no occasion for changing. All the others Simple Bodies require to have names devised for them. First there are the four simple gases. The name of Oxygen—'the generator of acids'—might readily be rendered by a corresponding Sanskrit compound; but this (as Mr. Mack has remarked) would only tend to preserve the exploded theory that there is no generator of acids besides Oxygen. Its old name of Vital Air connotes one of its most important characters, and therefore it has been here named *práṇa-prada*, or *práṇaprada-váyu*,—'the air that emphatically gives us breath.' Nitrogen (or Azote) we call *jivántaka*, 'that which would put an end to life.' Hydrogen is *jalajanaka*, 'the water-former; and Chlorine *harita* 'the greenish-coloured.'

Of the nine simple non-metallic bodies that are not gaseous, two, viz. Sulphur (*gandhaka*) and Carbon (*angára*), have Sanskrit names. Boron, as it is the basis of borax (*ṭanka*), we therefore call *ṭankopádána*; Silicon is the generator of flint,—*agnipra-sthara-janaka*; Selenium,—so named after the moon,—we have likewise named after the moon,—*chándra*,—it being a matter of moonshine what so rare and unimportant a substance be denomi-

nated. Phosphorus is *prakáśadá* 'the giver of light;' Bromine is *púta* 'the fetid;' Iodine is *aruṇa*,—the name, like the Greek one, referring to the violet-colour of its vapour; and Fluorine is *káchaghna-janaka* 'the generator of that (fluoric acid) which corrodes glass.'

Of those metals which have no names in Sanskrit only six are named in the present essay. Platinum, the 'heaviest' of metals, is, with allusion to its weightiness, named *gurutama*; and Potassium, the 'lightest,' *laghutama*. Sodium is 'the basis of culinary salt'—*lavaṇa-kara*; and Calcium, 'the basis of nodular limestone,'—*śarkará-kara*. Zinc, the Urdú name of which is *dastá*, we have named *dasta*—with allusion to the way in which its oxide, the 'philosophical wool', is 'tossed about' in the air. Tin, from its resemblance to silver in colour, we call *rajata-práya*.

Let such, then, be the names that we have to deal with in forming the names of Compounds;—and first of Binary compounds. Compounds must have names suggestive of the fact that they are *acid* or otherwise. The termination *ic* belongs to the Sanskrit as well as to the Latin,—so that Sulphur and Sulphuric Acid can be satisfactorily rendered *gandhaka* and *gándhakik-ámla*. To the acids in *ous* another termination (*ya*) has been appropriated. To the non-acid binary compounds, without attempting at present to fix separate terminations for the several varieties, the general termination *ja*—meaning 'produced from'—has been assigned. Thus an Oxide is *práṇaprada-ja*; a Chloride *harita-ja*; and so on. The Alkalis—potassa and soda—take feminine names, according to the analogy of the Latin, from those of their metallic bases,—thus—*laghutamá* and *lavaṇa-karí*.

Coming to the compounds of compounds,—as the acid affix *ic* changes to *ate* in the name of the resulting salt, the Sanskrit *ika* is replaced by *áyita*. Thus, as the Sulphuric Acid gives a Sulphate, the *gándhakik-ámla* gives a *gandhakáyita*. It should

be unnecessary to remark, that the suitableness of these names is not to be estimated on the principle which led the British sailor to set down the Spaniards as a nation of fools because they call a hat a *sombrero*. To the British sailor the word hat sounds much more natural than sombrero; and for like reasons Sulphate of Soda may seem to sound much more natural than *lavaṇa-karáyá gandhakáyitam*. But as 'hat' is not good Spanish, so 'Sulphate of Soda' is not good Sanskrit; and this leads us to forestall another criticism of kindred calibre. Is the sombrero-like expression, *lavaṇa-karáyá gandhakáyitam*, good Sanskrit? The question is not to be resolved by submitting the term to a Sanskrit grammarian ignorant of physical science,—to whom, without an attentive, serious, ingenuous, and uncavilling study of the tract in which it appears, the term has a *right* to be as obscure as the term Binoxalate of Potassa to the grandfathers of Lindley Murray.

It is intended that the present sketch of the science, after its phraseology shall have been more fully tested, shall form the text for a commentary in which the topics will be more fully treated, —directions being furnished also for the performance of experiments and the conducting of processes illustrative of the doctrine.

Benares College,
1st July 1852.

J. R. B.

BOOK THIRD.

SECTION I.

INTRODUCTORY.

a. At the end of the First Book we mentioned the reason for now proceeding to consider the properties of Number and Magnitude abstractedly considered,—that is to say, independently of any consideration of the particular things numbered or measured.

b. The science of determinate numbers is called Arithmetic.

SECTION II.

ARITHMETIC.

c. The following is probably what suggested the employment of the decimal notation.

Aphorism I.

Numbers are made to increase by tens because men have ten fingers.

a. On looking at an assemblage of objects,—say of men,—if the spectator wishes to ascertain or to remember the number, he may use his fingers as the means of notation. Let him hold up a finger for each man, and give a name, "one," "two," "three,"

and so on, to each finger. When he has come to the last finger, he must begin a new set, and he must note in some way how many sets there were in all. It is probable that this was the origin of the method of notation in general use, where the values of the figures, in the successive places, increase by tens. If men had had twelve fingers, the values of the figures would probably have been made to increase by twelves.

b. The rules for calculation derived from this science may be studied in Bápú Deva's treatise.

c. The ordinary rules of computation are inconvenient when we have to deal with very large numbers. In such cases we may make use of the method of *Logarithms*, some account of which here follows.

Aphorism II.

By means of Logarithms the processes of multiplication and division can be reduced to those of addition and subtraction; and involution and the extraction of roots can be effected by a single multiplication or division.

a. Take a set of numbers, each number exceeding the number preceding it by a given difference, and let the first number in the set be equal to the given difference; as 1, 2, 3, 4, 5, &c., where the difference is 1. Then take another set of numbers such that each is equal to twice or thrice or any fixed number of times the one before it, the first number in the set being equal to the multiplier, as 10, 100, 1000, 10000, &c., where the multiplier is 10. Write the second set of numbers under the first set, thus—

1	2	3	4	5	6	7
10,	100,	1000,	10000,	100000,	1000000,	10000000,

then the numbers in the upper line will be the Logarithms* of those in the lower, and the facts asserted in the Aphorism will be found true as follows.

b. Take the sum of two of the numbers in the upper line, and there will be found in the lower line opposite that number the product of the numbers which stand in the lower line opposite to the numbers the sum of which was taken. For example, of the two numbers 2 and 4 in the upper line, the sum is 6; and under 6 is found the number 1000000; and this is equal to the product of the numbers 100 and 10000, which stand beneath 2 and 4.

c. Again, if you take the difference of two numbers standing in the upper line, then you will find in the lower line, opposite that difference, the quotient which arises by dividing the greater by the lesser of the numbers standing under those the difference of which was taken. For example, the difference of 6 and 4 is 2, and under 2 you will find 100, which is the quotient of 1000000 divided by 1000, the two numbers standing under 6 and 4.

d. Again, if you multiply or divide, by any number, one of the numbers in the upper line, then you will find, under the number thus obtained, the corresponding power or root of the number standing under the number multiplied or divided. For example, multiply by 3 the number 2 in the upper line, and under the product, 6, you will find 1000000, which is the third power of 100, the number standing under 2.

e. The logarithms of all the numbers from 1 up to many thousands have been calculated and arranged in tables, from which

* The word Logarithm means "the number of the ratios." If the ratio is 10 then $10^1=10$, or the logarithm of 10 is 1; $10^2=100$, or the logarithm of 100 is 2, 1 being to 100 in the *duplicate* ratio of 1 to 10, and so on.

the logarithm of any particular number can be readily ascertained.

Aphorism III.

Symbols of processes are employed for shortness.

a. That is to say, certain signs are employed in order to make the language of Arithmetic shorter. A cross placed between two numbers signifies that they are to be added together. Thus 2+4 means that 4 is to be added to 2.

b. Two parallel lines signify equality. Thus 2+4=6 means that 4 added to 2 is equal to 6.

c. A single line between two numbers signifies that the latter is to be subtracted from the former. Thus 6—2=4, six diminished by 2, is equal to 4; and it is clear that 6, diminished by any number except 2, cannot be equal to 4.

d. It often however becomes necessary to speak of something which is true, not of any one number only, but of all numbers. For example, take 5 and 2; their sum is 7, their difference is 3. If this sum and difference be added together, we get 10, which is twice the greater of the two numbers first chosen. If from the sum we subtract the difference, we get 4, which is twice the lesser of the two numbers. The same thing will be found to be true of any two numbers.

e. Hence if we have two sealed bags of rupees, the one containing a large number, and the other containing a small number, both numbers being unknown to us, we can assert with certainty that the sum of the rupees in both bags, added to the difference between the two, is equal to twice the number of rupees contained in the larger bag; and that the sum, diminished by the difference, is equal to twice the number of rupees in the smaller bag.

f. Taking the letter *a* to represent the unknown number of

rupees in the larger bag, and b to represent the unknown number in the smaller bag, we can assert that

$$(a+b)+(a-b)=2a, \text{ and } (a+b)-(a-b)=2b.$$

c. Such an employment of letters to denote quantities respecting which he can make assertions without knowing what the quantities are, has given rise to the science of Algebra.

SECTION III.

ALGEBRA.

Aphorism IV.

In Algebraical calculations the results are not particular but general.

a. In addition to the symbols already mentioned, the following are constantly employed in algebraical notation. A cross placed diagonally between two numbers signifies that they are to be multiplied together. Thus $a \times b$ means that the number denoted by a, whatever number it may be, is to be multiplied by the number which b stands for. This may be also represented by writing the letters together, thus ab. If $a=2$, and $b=3$, then $ab=6$.

b. When two letters are written, the one above a line and the other below it, it is signified that the upper is to be divided by the lower. Thus if $a=6$, and $b=2$, then $\frac{a}{b}=3$.

c. A number multiplied by itself, thus aa, is written thus a^2. This is called the square of a.

d. If again multiplied by itself, thus *aaa*, it is written thus a^3. This is called the cube of *a*.

e. The small figure written above the letter is called the index.

Aphorism V.

As the results of Algebraical operations are general, they furnish arithmetical rules.

a. For example:—when there are four numbers, the first of which contains the second exactly as many times as the third contains the fourth, the four numbers are said to be in proportion. For example, let the four numbers be represented by *a b c* and *d*; if *a* contains *b* exactly as many times as *c* contains *d*, then *a b c d* are in proportion. Suppose that *a* contains *b* three times, then $\frac{a}{b}=3$, and also $\frac{c}{d}=3$; and, as things that are equal to the same thing, are equal to one another, $\frac{a}{b}=\frac{c}{d}$.

b. Again, as the equimultiples of equals are equal, multiplying each by *bd*, we get $ad=bc$; that is to say, the product of the first and fourth, out of four numbers in proportion, is equal to the product of the second and third. This is the foundation of the very useful rule called the Rule of Three. In the Rule of Three, the first three terms of a proportion are given, and we are required to find the fourth. After determining the order of the terms from the conditions of the question, we multiply together the second and third. The product, we know, is the same as the product of the first and fourth, so that, in order to find the fourth, we have only to divide the product by the first term.

Aphorism VI.

The application of algebraical processes enables us to make discoveries respecting the properties of form such as would have been otherwise beyond our reach.

a. We shall briefly indicate the way in which this application is made. Suppose that we call an inch *one*—then a line of two inches will be represented by 2, a line of eight inches by 8, and a line of as many inches as are signified by the letter *a* will be represented by *a*. In like manner surfaces such as a parallelogram, and solids, such as a cube, can be represented by letters; and by performing algebraical operations on these symbols, new properties of the magnitudes are deduced.

b. There are some relations of form however which cannot be determined by the use of signs representing numbers. For example, the relation of the angles at the base of an isosceles triangle. Such relations of magnitude must be studied by the aid of lines, straight or curved; and this branch of the science of Quantity is entitled Geometry.

SECTION IV.

GEOMETRY.

c. Here a leading distinction among lines requires to be noticed at the outset.

Aphorism VII.

A straight line is one which never changes its direction. A curved line is one which continually changes its direction, so that no two successive points in it are in a straight line.

a. Hence if a point in a curve coincides with a point in a

straight line, it is impossible that the next points should coincide.

b. In the Elements of Euclid, the text-book of elementary Geometry, which has been published in Sanskrit by Pandit Bápú Déva, the only curve line admitted is the circumference of the circle.

c. The postulate on which Euclid's reasonings are based is this, that two figures are equal, the one of which either exactly covers the other, or can be divided into portions which, all taken together, will exactly cover it.

d. Thus, in the fourth proposition of his first book, he infers that two triangles are equal which have two sides and the contained angle respectively equal, because the one triangle, if laid upon the other, must exactly cover it.

c. But here a difficulty arose. We have already explained that if a point in a curve coincide with a point in a straight line, the next points in the two lines cannot possibly coincide. Hence when we come to compare surfaces bounded by straight lines with surfaces bounded by curve lines, we may go on for ever subdividing the one or the other without being able to bring about a coincidence of their boundaries.

d. As it was of great importance to the advancement of Astronomy and other sciences dependent upon the aid of Mathematics, that we should be enabled to carry out the comparison of rectilinear with curvilinear surfaces and solids to any degree of nicety which might be required, a number of ingenious methods were invented during the two thousands years between the time of Euclid and the time of Newton.

e. That which has superseded all the rest, the method of Newton, improved by the notation of the German philosopher

SECTION V.

THE DIFFERENTIAL AND INTEGRAL CALCULUS.

f. In the *Lílávatí* of Bháskara Áchárya, the following question is proposed. A peacock seated on the top of a pillar sees at some distance a snake, which tenants a hole at the foot of the pillar. The snake, at the sight of its enemy, makes for its hole, and at the same instant the peacock flies down in pursuit of it. The height of the pillar being given, and the distance of the snake from the foot of it, and also the comparative speed of the two animals, it is required to determine the point at which the peacock will pounce upon the snake.—Now this question cannot be solved without the aid of the Calculus. Bháskara Áchárya, perceiving that there is a point at which the peacock will meet the snake if he fly down in a straight line, assumes that he will fly in a straight line, and proceeds to deduce the consequences of the supposition. But if the peacock be not such a mathematician as to know this point, he will direct his flight continually towards the snake, and as the snake is continually changing its place, the direction of the peacock's flight will continually change, and this, as previously stated, is the characteristic of a curved line. The determination of the curve in question involves processes intelligible only to those who have attained to some proficiency in the study of the Calculus.

g. The solution of the following simpler case may be rendered intelligible to one who understands at least the common rules of Algebra.

h. It has been ascertained by experiment that a body dropped from a height falls towards the earth through rather more than 16

feet in the first second, four times as much, or 64 feet, in two seconds, nine times as much, or 144 feet, in three seconds, and so on—the space increasing according to the square of the time. A very little consideration of this fact must make it apparent that the rate of falling never continues uniform for even the smallest assignable portion of time; else, why should the rate, after having been uniform for any period, become changed without the intervention of a new cause? Now the rate of motion is always estimated by the distance gone over by some assumed uniform motion, in a given line; and suppose we wish to know the rate at which the body was falling exactly at the end of the third second, the rate must be something greater than it was immediately before, and something less than it was immediately afterwards. We must here premise the first proposition of Newton's *Principia*, which is as follows.

Aphorism VIII.

"Quantities which tend towards equality, and of which the difference, in the course of this approach, becomes less than any finite magnitude that can be assigned, must be ultimately equal."

a. "If this be denied, let them ultimately differ by a magnitude denoted by D. Then the difference between them cannot become less than this finite magnitude D, which is contrary to the hypothesis."

b. Now let us call 16 feet a *measure*; then the number of measures through which the stone falls in x seconds is x^2. Let us next suppose a very small portion of time h, and let the position of the stone, which fell from the point O, be A at the end of x seconds, B at the end of $x+h$ seconds, C at the end of $x+2h$ se-

conds, &c. Then the values of the lines, expressed in measures, are as follows:—

$OA=x^2$, $OB=(x+h)^2$, $OC=(x+2h)^2$, &c. —O

Whence —A

$AB=OB-OA=2xh+h^2=(2x+h)\,h$ —B

$BC=OC-OB=2xh+3h^2=(2x+3h)\,h$ —C

$CD=OD-OC=2xh+5h^2=(2x+5h)\,h$, &c. —D

c. From this we see that in the successive small portions of time denoted by h, the spaces traversed were in the ratio of

$$2x+h,\ 2x+3h,\ 2x+5h,\ \&c.$$

d. Since, the greater the space fallen through, the greater is the change of the rate, it follows that the smaller the space fallen through, the smaller is the change of the rate; or in other words the nearer does the rate approach to the condition of uniform motion.

e. The smaller then we suppose h to be, the more nearly will the foregoing expressions denote the uniform rate of motion at a given instant; and, according to the proposition quoted above, the expressions must ultimately coincide with the expression which we are in search of, if we carry the diminution of h to its extreme limit, or make it equal to *nothing*.

f. Now when h is made equal to nothing, all the above expressions become $2x$. So we find that the rate, at the end of any number of seconds, is twice that number of measures.

g. At the end therefore of three seconds when $x=3$, the stone, had its motion suddenly become uniform, would have passed, in the course of the next second, through 96 feet; for $2\times3\times16=96$; whereas, in consequence of its continual acceleration, it actually passes through 112 feet.

h. The line OA, the length of which is here supposed to vary by successive additions, is called a variable quantity.

i. Variable quantities, in this branch of enquiry, are represented by the letters x y z.

j. The portions A B, B C, C D, by which the successive values of the variable differ from each other, and which may be supposed indefinitely small, are called differentials.

k. The differential of x is written thus dx; and, in like manner, those of y and z, dy and dz.

l. The question which has been worked out above, would be proposed in the Differential Calculus in the following shape. "If x vary uniformly, at what rate will x^2 vary?" We have seen that it will vary 2 x times as fast; so that if the differential of x be dx that of x^2 is $2xdx$.

m. By comparing $2xdx$ with x^2, we arrive at the first rule for differentiation, viz. "Multiply by the index, diminish the index by unity, and multiply by the differential of the independent variable."

n. The following are examples of differentiation;—$d.\ x^3$, that is to say the differential of the cube of x, is equal to $3x^2dx$; and again, $d.ax^4 = 4ax^3dx$.

o. The coefficient, or multiplier, of dx in these expressions is called the *differential coefficient*.—Thus, in $4ax^3dx$, the differential coefficient is $4ax^3$.

p. When the value of a quantity depends upon the particular value of another variable quantity, the one quantity is said to be a *function* of the other.

q. Thus, the area of a square, depending on the length of its side, is said to be a *function of the side.*

r. The object of the Differential Calculus is to determine the differential of any given function.

s. The object of the Integral Calculus is the converse of this, viz. to ascertain the function from which a given differential has been derived.

t. The first rule for integration is therefore the converse of that for differentiating.—viz." Add one to the index, divide by the index thus increased, and by the differential of the variable."

u. By thus treating the differential $2xdx$ we recover the function x^3.

v. The symbol of integration is a long shaped *s*,—thus $\int 2xdx = x^2$.

SECTION VI.

PARENTHETICAL.

w. By means of the various methods of calculation which we have now briefly characterised, we are in many cases able to arrive deductively, or *à priori*, at a correct prediction of what will arise from the conjunct agency of several causes; —e.g. of two forces acting on a single body.

x. In order that we may correctly predict the result of the conjunct agency of several causes, it is only necessary that the same law which expresses the effect of each cause acting by itself shall also correctly express the part due to that cause, of the effect which follows from the two together.*

* The paragraphs in this section are mostly taken from Mr. John S. Mill.

y. This condition is realized in the extensive class of phenomena called mechanical, namely the phenomena of the communication of motion (or of pressure, which is tendency to motion,) from one body to another.

z. In this class of cases of causation, one cause never, properly speaking, defeats or frustrates another. If a body is propelled in two directions by two forces, one tending to drive it to the north, and the other to the east, it is caused to move in a given time exactly as far in *both* directions as the two forces would separately have carried it; and is left precisely where it would have arrived, if it had been acted upon first by one of the two forces, and afterwards by the other.

aa. This law of nature is called the principle of the Composition of Forces; and the name of the Composition of Causes may be given to the principle which is exemplified in all cases in which the joint effect of several causes is identical with the sum of their separate effects.

ab. The principle of the Composition of Causes by no means prevails in all departments of the field of nature. The combination of two substances often produces a third substance with properties entirely different from those of either of the two substances. For example, when mercury, which is a fluid metal with a silvery colour, combines with sulphur, the colour of which is yellow, the substance produced, viz. vermilion, is of a bright red. Again, when lead, which has no taste, combines with vinegar, which has a very sour taste, a poisonous white salt is produced, which, from the sweetness of its taste, is vulgarly called sugar of lead.

ac. The investigation of the laws to which inanimate substan-

ces conform when their properties in combination are not the sum of their properties separately, is the province of Chemistry.

SECTION VII.

CHEMISTRY.

ad. In this science, bodies are regarded first under the following division.

Aphorism IX.

Bodies are Compound or Simple.

a. A Compound body is such as vermilion [§ VIII. *ab.*], which, for example, is compounded of mercury and sulphur.

b. That body, such as sulphur, which, so far as we can discover, is not compounded of any other bodies, we call a simple body.

c. Compound bodies are innumerable. These are all formed out of the simple bodies, of which there are reckoned above fifty five.

Aphorism X.

The Simple Bodies are divided into Metals and Non-metallic bodies.

a. The Metals are such as Gold, Iron, Mercury &c. The Non-metallic bodies are Sulphur &c.

Aphorism XI.

The Non-metallic simple bodies are divided into those that are in the form of Air, and those that are not so.

a. By an Air we mean a fluid indefinitely elastic, and permanently so at ordinary temperatures and under ordinary pressure.

The steam of boiling water is indefinitely elastic, but it loses its elasticity at ordinary temperatures, and this distinguishes it from Airs.

b. Airs are divided into the common Air which we breathe and other Airs,—these latter, for the sake of distinction, being called Gases.

Aphorism XII.

The simple Airs, or Gases are four in number.

a. These are named Oxygen (—also 'vital air'—), Nitrogen (—or Azote—which means incapable of sustaining life) Hydrogen (i. e. 'the former of water'), and Chlorine (i. e. the 'greenish yellow' gas).

b. Oxygen is called 'vital air' because men cannot live without it. Oxygen has no taste and no smell; and in a glass vessel full of it, we can discern no more colour than we can discern in a vessel when filled with common air. What, then, is the difference between common air and Oxygen? One difference is the superior vivacity with which inflammable bodies burn in Oxygen.

c. A piece of wood with a spark of fire just on the point of being extinguished, will commence blazing if plunged into Oxygen.

d. Even iron burns in it like tinder.

e. Phosphorus, an inflammable substance obtained from bones, burns in Oxygen with a brilliancy like that of the sun.

f. We have said that men cannot live without Oxygen. But yet men live in common air. How is this? Because there is

Oxygen in common air. But if there is Oxygen in common air, why does a piece of wood with a spark not begin blazing, and why does iron not blaze when heated? It is because the Oxygen in the common air is mixed with and diluted by another gas,—viz. with Nitrogen.

g. Nitrogen, like Oxygen, has no taste, and no smell, nor can any colour be discerned in a glass vessel filled with it. What then is the difference between this gas and Oxygen? One difference is this, that an inflamed substance is extinguished when it is placed in pure Nitrogen. If, therefore, the common air had consisted of Nitrogen alone, nothing could have burned; and if it had consisted of Oxygen alone, every spark would have led to a conflagration. By the mixture of the two gases, in the proportions in which they exist in the atmosphere, both of these inconveniences are avoided.

h. The proportion of Nitrogen to Oxygen in the atmosphere is that of four to one. This may be illustrated as follows. Place a light, so that it may float, on the surface of a vessel of water. Invert over it a large bell-glass, such as a wall-shade, so that the edge of the glass may dip a little under the water. In a little while the Oxygen will be exhausted by the combustion, the light will be extinguished, and the water will rise into the jar,* showing that at least so much of the air is no longer present in its previous form.

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* In order that nothing but Nitrogen may be left to exclude the water, phosphorus is the substance that must be burned. If an ordinary light be employed, the carbonic acid gas produced by its combustion retains much of the room of the oxygen. A few drops of Alcohol, lighted in a small floating cup, may be conveniently employed in this experiment.

i. Water consists of Oxygen and of another gas which is called Hydrogen, i. e., 'the producer of water'. Hydrogen, like Oxygen and Nitrogen, has neither taste nor smell; and a glass jar filled with it appears colourless.

j. In respect of combustion, Hydrogen is the opposite of Oxygen. A lighted taper plunged into Hydrogen is extinguished while the Hydrogen itself takes fire.

k. Hydrogen is the lightest of all known bodies. A balloon filled with it rises higher into the air than any bird can fly; and if the balloon is a large one it is capable of raising to that height a car containing several persons.

l. Chlorine is a gas which differs from the other simple gases in several respects. Its colour is greenish yellow. Its odour is extremely pungent and irritating, and its taste is analogous.

m. Several substances inflame in it spontaneously. Such are copper, in fine leaves; phosphorus; mercury, &c.

n. It destroys all animal and vegetable colours, and hence it is very useful in bleaching. It also destroys the volatile products of decaying animal or vegetable substances, thus removing the offensive odour and other bad effects which are apt to arise from such a source in hospitals, prisons, &c.

Aphorism XIII.

The Simple Non-metallic bodies which are not gaseous, are nine in number.

a. These are named Carbon, Boron, Silicon, Sulphur, Selenium, Phosphorus, Bromine, Iodine, and Fluorine.

b. Carbon (or charcoal) is the black substance which is left

when wood is heated and the air excluded, or when the embers are extinguished by throwing water upon them.

c. Boron is a brown powder, which is a constituent of the substance called borax.

d. Silicon is a brown powder, which is a constituent of that hard substance, which strikes fire with steel, called flint (—or, in Latin, silex).

e. Sulphur is a well known inflammable yellow substance.

f. Selenium is a rare substance which in many respects resembles sulphur.

g. Phosphorus is a substance which in appearance resembles wax. It shines in the dark; and a degree of heat less than that of boiling water is sufficient to inflame it. As it takes fire on being rubbed, it is employed in making the matches called lucifer matches.

h. Bromine is a dark red fluid with a very disagreeable smell (—as its name implies).

i. Iodine is a substance of a bluish black colour with a metallic lustre. Its smell resembles that of chlorine. When heated, it assumes the form of a vapour, which (as the name implies) is of a fine violet colour.

j. The name of Fluorine is given to a supposed element in a mineral called Fluor spar.

Aphorism XIV.

The Metals are forty-six in number.

a. Some of these, as Gold, Silver, Copper, and Lead, are famil-

iarly known. Of the remainder, some are very rarely met with, and need not be here described. We shall describe at present only those of the metals which it is desirable that the reader should become acquainted with.

b. Platinum is the heaviest of the metals, being heavier even than Gold. It is white like Silver.

c. Mercury differs from the other metals in being fluid at ordinary temperatures. In the cold air near the north pole it becomes solid, and it may then be hammered into leaves like iron or copper. When strongly heated, it rises in vapour.

d. Tin is a metal which resembles silver in colour and lead in softness.

e. Zinc is a metal with a leaden colour. It takes fire in the air when heated red-hot, and floats in the air like flocks of wool.

f. Potassium is a metal which is so light that it swims upon water, where, at the same time, it inflames spontaneously.

g. Sodium also floats when thrown upon water, but it does not, like Potassium, inflame.

h. Calcium is a metal which is the basis of lime.

i. Of the simple substances which have been now partly described, all the bodies with which we are acquainted on the earth's surface are made up.

j. If any substance, such as salt or chalk, is made up of several simple substances, it is desirable that it should have a name suggestive of its component elements.

Aphorism XV.

In chemical enquiries let compound substances receive names suggestive of their component elements.

a. For example,—common salt is a compound of Chlorine and Sodium, and its chemical name is Chloride of Sodium.

b. Beginning with Oxygen, we shall now notice how the several Simple Bodies enter into compounds.

c. We have already stated that the atmosphere consists mainly of one part of Oxygen mingled with four parts of Nitrogen. The product of this mixture is not reckoned a chemical compound, because, as has been already explained, chemical composition is considered to have taken place, only when the qualities of the product are not what could have been predicted by taking together the properties of the separate ingredients.

d. Of the chemical compounds of Oxygen with Nitrogen there are five. The five compounds, in the order in which we shall take them, differ from one another in having each a larger proportion of Oxygen than the one before it in the list.

e. The first compound of Oxygen with Nitrogen is a gas which if a man breathes he laughs violently, and becomes for a time like one deranged.

f. The second compound of Oxygen with Nitrogen is a colourless gas, which, when allowed to mingle with the atmosphere, attracts an additional quantity of Oxygen and becomes red.

g. Charcoal and Phosphorus burn brilliantly in the second compound of Oxygen and Nitrogen; but this gas cannot be breathed, because if it were to mingle with the common air in the lungs,

it would form the red gas already mentioned which is poisonous.

h. The third compound of Oxygen and Nitrogen, which is procured with difficulty, is an acid which does not here require special notice.

i. The fourth compound of Oxygen and Nitrogen is the red gas already mentioned. Water absorbs it readily.

j. The fifth compound of Oxygen and Nitrogen cannot be procured separately. In combination with water it is an acid which corrodes the flesh, and dissolves iron &c.

k. We have said [—see § 14. *j.*—] that it is desirable that substances should, in chemical enquiries, be denoted by names suggestive of their component elements; but, from what has now been said of the compounds of Oxygen and Nitrogen, it must be obvious that the name ought to suggest not merely the elements but the relatively greater or lesser proportion of the elements in each compound. For example, the name of the second compound of Oxygen and Nitrogen ought to suggest its containing a greater proportion of Oxygen than the first compound. How this is effected, we proceed to explain,—premising some remarks on the various habits of various bodies in regard to their combining.

Aphorism XVI.

In the union of some bodies no limitation is observed with regard to the relative proportions in which they unite.

a. For example,—with a certain quantity of milk, a small quantity of water, or a large quantity of water, mingles equally well.

Aphorism XVII.

Some bodies combine in all proportions as far as a certain point, beyond which, combination no longer takes place.

a. Thus a certain quantity of water will dissolve common salt until a certain quantity has been dissolved, after which all the salt added remains undissolved. [This kind of limitation is called Saturation].

b. Since, in the two kinds of combination just described, the sensible qualities belonging to the combining substances in their separate state, either continue to be apparent in the compound which they form, or are not permanently altered, such combination is not strictly termed *chemical*: [—see § VIII. *ab.* and *ac.*]

Aphorism XVIII.

Bodies which unite chemically do so in certain fixed or definite proportions; and when bodies unite chemically in more than one proportion, the quantity of one element in each compound is found to be a simple of its quantity in the first.

a. Thus in the five compounds of Oxygen with Nitrogen above-mentioned, the proportions are those of 14 parts of Nitrogen to 8, 16, 24, 32, and 40 parts of Oxygen respectively.

Aphorism XIX.

The proportions in which two elements combine with *Hydrogen* indicate the proportions in which those two elements combine also with each other.

a. For example, 35 parts of Chlorine combine with one of Hydrogen [to form Hydrochloric acid], and 8 parts of Oxygen combine with one of Hydrogen [to form Water]; and the compounds of Chlorine with Oxygen contain 35 parts of chlorine combined with 8, 32, 40, and 56 parts respectively of Oxygen. Now the numbers 8, 32, 40, and 56, are not successive simple

multiples of 8, for these would be 8, 16, 24, 32, 40, 48, 56; therefore the law under consideration [—which is called the law of Definite Proportions] suggests the probability that there are at least three different compounds of Oxygen and Chlorine yet undiscovered.

b. Having ascertained that substances combine chemically in fixed proportions, chemists have inferred that the elementary bodies are not, like space, infinitely divisible, but that they consist of minute indivisible particles,—called Atoms.

c. It is supposed that the Atoms, though exceedingly small, are not devoid of magnitude [—as is supposed in the Nyáya;—see § XL. *b.* Book II].

d. It is also supposed that the atoms of any one element,—say of Gold—are alike in weight, but that they differ in weight from the atoms of other elements.

d. When bodies combine in only one proportion, it is supposed that the combination is of one atom of the one with one atom of the other; and when they combine in more proportions than one, that the combination is of one atom of the one with one, two, three, four, &c. of the other.

e. From this it follows that the numbers expressing the combining proportion express also the relative weights of the atoms of the combining elements.

f. This will appear clearly if we consider that if eight pounds of one element combine with one pound of another element so as to form nine pounds of a compound substance, in which each atom of the one element is joined to an atom of the other element, then an atom of the one element must be just eight times as heavy as an atom of the other.

g. The following is a table of the comparative atomic weights (or chemical equivalents) of the most important elements, with their symbols.

Oxygen 8.	O	Copper 32.	Cu
Nitrogen 14.	N	Iron 28.	Fe
Hydrogen 1.	H	Lead 104.	Pb
Chlorine 35.	Cl	Platinum 98.	Pt
Carbon 6.	C	Mercury 100.	Hg
Boron 11.	B	Zinc 32.	Zn
Sulphur 16.	S	Potassium 40.	K
Phosphorus 32.	Ph	Sodium 23.	Na
Gold 98.	Au*	Calcium 20.	Ca
Silver 110.	Ag		

h. When treating of the chemical composition of bodies it is found convenient to denote the elements by short symbols, as in Algebra:—[see § 3. *c* B. III]. Among the symbols in use are those given in the above table.

i. Each symbol is understood to stand for as many parts, by weight, of the element, as there are units in the number denoting its atomic weight or combining proportion. Thus O stands for 8 parts, by weight, of Oxygen; N for 14 parts of Nitrogen; H for 1 part of Hydrogen; and so on.

j. By combining the symbols of the elements we obtain the symbols of their compounds. Thus since the symbol Na stands for 23 parts of Sodium, and Cl for 35 parts of Chlorine, the symbol Na+Cl stands for 58 parts of Chloride of Sodium (or common salt—see § 15 *a.*) And this number 58 represents the atomic weight of Chloride of Sodium. The like remark applies to the atomic weights of all compounds.

* From the Latin *aurum*,—and so of the others.

k. Having determined thus much in regard to the principles of combination, let us revert to the five compounds of Oxygen with Nitrogen [§ 15. *d*]. From what is remarked under Aph. 18 and 19 *d.*, it will be understood how the symbolic formulæ and the atomic numerals of the five compounds of Oxygen and Nitrogen are as follows.

1st compound	N+O	22
2nd —	N+2O	30
3rd —	N+3O	38
4th —	N+4O	46
5th —	N+5O	54

l. An inspection of these symbols will show that, in these five compounds there is such a difference in the relative proportions of the elements as will require [see § 15. *k*] to be suggested by the chemical name of the compound. But there is another consideration which prevents us from giving to the five a set of names suggestive of nothing more than this distinction. For example, some of the compounds of Oxygen with Nitrogen are *acid*, and others are not. This difference being, for reasons which will appear in the sequel, a very important one, it requires to be recorded in the name of the compound; and, with reference to this, we propound the following aphorism.

Aphorism XX.

Compounds of the elements ought to have names suggestive of the fact that they are *acid* or otherwise.

a. Of the five compounds of Oxygen and Nitrogen three are *not* acid, and these, accordingly, are named, simply with reference to their having respectively the first, the second, or the third and greatest proportion of Oxygen, as follows.

The Protoxide of Nitrogen.
The Deutoxide of Nitrogen.
The Peroxide of Nitrogen.

b. Of the compounds of Oxygen and Nitrogen the remaining two are acids. Let us consider how these are to be distinguished.

c. When any substance, by combining with two different proportions of Oxygen, is capable of forming two distinct acids, that acid which contains the larger proportion of Oxygen is distinguished by the syllable *ic* at the termination of its name, and the other, containing the lesser proportion of Oxygen, is distinguished by the termination *ous*. Accordingly the third and fifth compounds of Nitrogen with Oxygen, which are acids, are respectively named Nitrous acid and Nitric acid. The names of the five compounds of Oxygen with Nitrogen are therefore as follows.

1 Protoxide of Nitrogen.
2 Deutoxide of Nitrogen.
3 Nitrous acid.
4 Peroxide of Nitrogen.
5 Nitric acid.

d. Having considered the compounds of the two first elements with one another, we now turn to the third element —viz.—Hydrogen—and enquire what compounds it forms with the two preceding elements.

e. Hydrogen and Oxygen, atom to atom, produce water. The proofs of this fact will be given hereafter. The symbol of water accordingly is H+O, and its atomic numeral 9.

f. Hydrogen combining with Nitrogen produces Ammonia, a gas with a very pungent odour. This gas eagerly combines with

water. In Ammonia there are three atoms of Hydrogen to one of Nitrogen, so that its symbol is 3 H+N, and its atomic numeral 17.

g. Chlorine, the fourth in our list, combines with Oxygen, with Nitrogen, and with Hydrogen, forming a variety of compounds, among which we shall notice at present only that with Hydrogen. This Compound is a pungent acid gas, termed Hydrochloric Acid, which unites eagerly with water. Its symbol is Cl+H, and its atomic weight 36.

h. We have next to consider the combination of the second class of elements with the first.

i. Carbon, in combination with Oxygen, produces an acid gas, Carbonic Acid. This gas is fatal to animal life. It is so heavy that it may be poured from one vessel into another like water. Hence, in some wells and caverns where it is formed naturally, it occupies the lower parts, whilst the upper parts are free from it; and in the same place, therefore, where a dog is killed by it, a man, from his superior height, is unhurt. The symbol of Carbonic Acid is C+2 O, there being two atoms of Oxygen to one of Carbon. Its atomic weight is 22.

j. When a diamond is burned in Oxygen gas, the result is Carbonic Acid. This shows that the diamond consists of carbon.

k. Carbon with Nitrogen produces an inflammable gas with a penetrating and peculiar smell,—the Carburet of Nitrogen.

l. With Hydrogen Carbon forms an inflammable gas, carburetted Hydrogen—which may frequently be obtained from stagnant pools by stirring the mud. This gas in some places, as at Jwálámukhí in the Panjáb, issues from the ground in such quan-

tities that it can supply a continual flame. A gas of this kind may be extracted from coal. In Europe it is employed to light up the streets.

m. Sulphur, combined with three atoms of Oxygen, produces Sulphuric Acid, a gas which readily unites with water. Its symbol is S+3 O, and its atomic weight 40.

n. Phosphorus, combined with five atoms of Oxygen, forms Phosphoric Acid. Its symbol is Ph+5 O, and its atomic weight 72.

o. Phosphorus combined with Hydrogen produces a gas which inflames spontaneously in the air. It is named Phosphuretted Hydrogen.

p. We have now to consider the combination of the Metals, the elements of the third class, with those of the other classes and with one another.

q. The combinations of most metals with Oxygen are commonly termed *rusts.* Gold and Silver have very little disposition to combine with Oxygen. They do not *rust;* and this is one reason why they are well adapted for making coins &c.

r. The Common red Oxide, or rust, of Iron consists of two atoms of Iron to three of Oxygen. This ratio being that of 1 to 1½, the red rust of iron is called the Sesqui-Oxide* of Iron.—Its symbol is 2 Fe+3 O, and its atomic weight 40. There is a Protoxide of Iron, the symbol of which is Fe+O, and the atomic weight 36. The sparks that fly off from a mass of hot iron, when hammered by the blacksmith, consist of this Oxide.

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* From the Latin prefix *Sesqui,* signifying half as much more.

s. Of Lead the Protoxide (litharge) is yellow, and the Deutoxide (minium) is red.

t. The Peroxide of Mercury is of a red colour.

u. With Chlorine Mercury forms two compounds. The Protochloride of Mercury (calomel), a tasteless white powder, is a valuable medicine. The Perchloride of Mercury (corrosive sublimate) is highly poisonous.

v. With Sulphur, as already mentioned, [see § 8. *ab*], Mercury forms a brilliant red powder—the Bisulphuret of Mercury (vermilion).

w. Mercury combines readily with several of the metals. Combined with gold it is employed in gilding vessels of silver.

x. The Oxide of Potassium, called Potassa, is a white substance with an intensely acrid (alkaline) taste. It corrodes the flesh. Its symbol is K+O, and its atomic weight 48.

y. The Oxide of Sodium, called Soda, very much resembles that of Potassium. Its symbol is Na+O, and its atomic weight 31.

z. With Chlorine, as already mentioned [see § 15. *a.*] Sodium forms common salt. The symbol of Chloride of Sodium [common salt] is Na+Cl, and the atomic weight 58.

aa. The Oxide of Calcium is commonly called lime. Its symbol is Ca+O, and its atomic weight 28.

ab. Having now considered the *binary* compounds,—those into which only two elements enter,—we have next to consider those compounds into which a greater number of elements enter. In *Aph.* 20 the distinction between Acids and other compounds has been adverted to. One distinction which belongs to most

acids, as is implied in the name, is a sour taste. Another characteristic, or *test*, is this, that they change a vegetable blue infusion, such as that of the Hibiscus flower, to red. Among the binary compounds there are others which, like Potassa, have an acrid taste [and which are termed *alkalis*], which restore the blue colour to the infusion, or which go further and change it to green With these alkalis, as well as with other oxides, the acids are disposed to form further compounds, in regard to which we remark as follows.

Aphorism XXI.

Acids combine with Oxides to form Salts.

a. It has already been mentioned that common salt is a compound of Chlorine and Sodium ; so that it is not now asserted that *all* salts are compounds of acids and oxides, but only that very many are so; and of these we now proceed to give some account.

b. Acids as already mentioned [—see § 20. *c.*] have names ending in *ic* or *ous*. In the name of the salt the *ic* is changed to to *ate*, and the *ous* to *ite*. Thus a salt into which Nitric Acid enters is called a Nitrate, and one into which Nitrous Acid enters, a Nitrite.

c. As it is always with the *Oxides* of the metals that the Acids enter into combination, it is not necessary to notice this in naming the salt, unless when more than one oxide of the same metal combines with acids. Thus, instead of Nitrate of the Oxide of Silver, it is sufficient to say Nitrate of Silver, but we must distinguish between the Sulphate of the Protoxide of Iron, and the Sulphate of the Sesquioxide of Iron.

d. In the following list, the Acid and Oxide in each case is

mentioned in the left hand column, with the respective symbols and atomic weights, and the resulting symbol and atomic weight in the right-hand column.

Nitric Acid=N+5O=54. } Nitrate of Potassa
Potassa=K+O=48. } =KO+N 5O=102.

Nitrate of Potassa is the well-known salt, commonly called Nitre or Saltpetre, which is employed in the manufacture of gunpowder.

Nitric Acid=54. } Nitrate of Ammo-
Ammonia=3H+N=17. } nia=71.

Nitrate of Ammonia is employed in the preparation of the Protoxide of Nitrogen, the gas which intoxicates one who breathes it: [see § 15. *e*].

Nitric Acid=54.
Oxide of Silver=Ag+O } Nitrate of Silver
=118. } =172.

This salt is employed by medical men as a caustic: (—lunar caustic).

Sulphuric Acid=S+3O
=40. } Sulphate of Soda
Soda=Na+O=31. } =NaO+S3O=71.

Sulphate of Soda is one of the salts employed in the galvanic battery.

Sulphuric Acid=40. } Sulphate of Lime
Lime=Ca+O=28. } =68.

Sulphate of Lime (—commonly called Plaster of Paris—) is white like chalk. It is much employed in making statues by means of a mould.

Sulphuric Acid=40.
Oxide of Copper=Cu+O =40.
} Sulphate of Copper =80.

Sulphate of Copper (—commonly called blue vitriol—) is a well-known salt which is employed in the galvanic battery.

Sulphuric Acid=40.
Protoxide of Iron=Fe+O =36.
} Sulphate of the Protoxide of Iron=76.

This salt, being of a green colour, is commonly called green vitriol.

Hydrochloric Acid=36.
Ammonia=17.
} Hydrochlorate of Ammonia=53.

This salt, commonly known as Sal Ammoniac, is employed in cooling water, and for many other purposes.

Carbonic Acid=C+2 O =22.
Lime=28.
} Carbonate of Lime =50.

The substance commonly known as Chalk, is a Carbonate of Lime.

Boracic Acid=B+6 O =68.
Soda=31.
} Borate of Soda =99.

This salt is the substance well known as Borax.

Phosphoric Acid=Ph. +5 O=72.
Lime=28.
} Phosphate of Lime =100.

This salt is the principal ingredient in the bones of men and other animals.

e. Thus far we have been engaged in tracing the Elements through their successive combinations until we arrive at some of the well known compound substances which men daily make use of. The production of a substance by the combination of the proper ingredients is called *Synthesis.** The converse process, where we decompose a compound in order to determine what are its constituent elements, is called *Analysis.*†

Aphorism XXII.

The analysis of Chemical compounds is effected by Heat, by Electricity, or by the introduction of some substance having a stronger attraction for one of the substances united than they have for each other.

a. For example, the red Oxide of Mercury [§ 20. *t.*] when heated, is resolved into metallic Mercury and Oxygen gas. This furnishes one means of procuring Oxygen in a separate state. The method of conducting the operation will be explained in a treatise subsidiary to this Synopsis.

b. Water is decomposed by Electricity into Hydrogen and Oxygen.

c. Sulphate of Copper (the *túṭiyá* or blue vitriol of the bázárs) may be decomposed by dipping a polished piece of iron into a solution of the salt. The acid, having a stronger attraction for the iron than for the copper, unites with the iron, and deposits the copper on its surface. When the whole of the copper

* From a Greek word signifying "to put together."

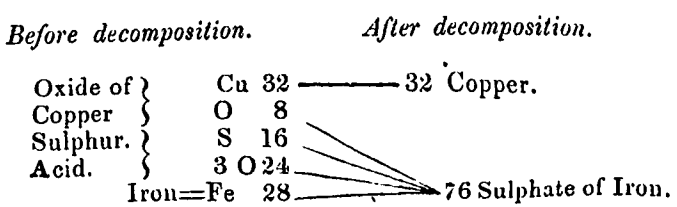
† From a Greek word signifying "to unloose."

has been deposited, the solution will be found to consist of Sulphate of Iron (the *kasís* or green vitriol of the bázárs).

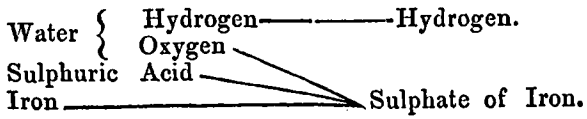
d. The comparative attractions of various substances having been first ascertained by experiment, have been registered by chemical enquirers in tables, by referring to which we learn what substances to employ in decomposing any compound body.

e. The Atomic number of any substance is also called its *equivalent* number, because it indicates the proportional number of pounds or ounces of the substance which are exactly sufficient to supply the place of another substance in a compound. Thus, in the experiment cited above, if there were 31 ounces of copper in the solution of blue vitriol, it would be found that 28 ounces of iron were sufficient to supply the place of the copper; or, in other words, that the acid which had dissolved 31 ounces of copper, could dissolve no more than 28 ounces of iron. The powers of saturation of iron and copper have thus been experimentally ascertained to be in the ratio of 28 to 31, as is recorded in the table [at § 19. *g.*] A knowledge of the equivalent numbers saves the chemist from all doubt as to the exact quantity of any substance which is necessary to effect any proposed composition or decomposition.

f. Substituting the symbols for the names of the Sulphate of Copper and of the Iron, the result of the decomposition may be concisely expressed as follows.



g. It will be observed that, in accordance with the principle of Chemical Equivalents, the quantity of Oxygen that was required to make the 32 parts of Copper in the salt into an Oxide [see § XXI. *c.*], is just the quantity that is required to make the 28 parts of Iron into an Oxide. If the Iron, instead of being dipped into a solution of Sulphate of Copper, is immersed in a watery solution of Sulphuric Acid, then, in order to combine with the acid, it takes the necessary supply of Oxygen from the *water*. The consequence is that the Hydrogen of the water is set free, and comes away in the shape of bubbles. This decomposition may be illustrated as follows.

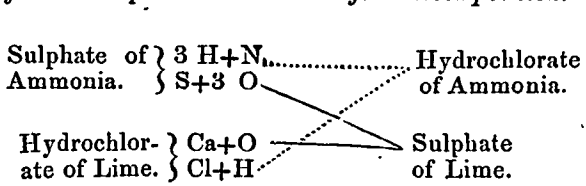


This furnishes one means of procuring Hydrogen in its separate state. How to collect it as it comes away will be explained in a subsidiary treatise.

h. In the foregoing examples one out of three substances, by taking possession of the second, turns the third adrift. In certain cases of decomposition there are four substances forming two compounds, which two, on meeting, make a mutual exchange of an ingredient. For example, let Hydrochlorate of Lime dissolved in water,* be mixed with a solution of Sulphate of Ammonia:—the Sulphuric Acid will combine with the Lime, and the

* The intelligent chemist will understand that the change of the chloride into a hydrochlorate, on solution in water, does not affect the principle to be exemplified, and is not therefore here adverted to.

Hydrochloric Acid, instead of flying off (as it would have done if Sulphuric Acid alone had been added) combines with the Ammonia which the Sulphuric Acid had deserted. This may be represented as follows,—the continuous lines showing the direction of the one pair of ingredients from left to right, and the dotted lines the direction of the other pair.



i. We have hitherto considered only such products of the elements as can be reproduced, by merely human means, after their elements have been separated. The red Oxide of Mercury, for example, may be separated into Mercury and Oxygen [§ 22. *a.*]; but we can very easily cause the Mercury to recombine with Oxygen and to reappear in the form of the red Oxide. It is otherwise, however, with certain other substances. We can decompose a piece of wood, and ascertain that it consists of Oxygen, Hydrogen, and Carbon; and we can decompose a piece of flesh, and ascertain Nitrogen, and Carbon; that it consists of Oxygen, Hydrogen, but we cannot, out of these elements, reproduce, in our laboratories, either wood or flesh. To the reproduction of these another principle is indispensable, viz. *life.*

Aphorism XXIII.

The principle of Life modifies chemical action.

a. A seed of a plant, placed in the earth, produces changes in

the matter taken up into the plant which cannot be imitated by art. For example, the seed of the Madder developes a well known colour which can be derived from no other source; and the seed of the Mango produces a fruit the flavour of which is equally inimitable. Let us, then, now turn to the consideration of plants, the peculiar nature of which furnishes the province of Botanical science.

SECTION VIII.

BOTANY.

b. Plants are regarded first under the following division.

Aphorism XXIV.

Plants either have visible flowers, or they have not.

a. Among the plants which have no visible flowers are the mushrooms. Plants with visible flowers are such as the Mango-tree, &c.

b. The *Ficus religiosa* and other fig-trees are not to be reckoned among plants with invisible flowers, because their flowers, inside of the fruit, are visible by the aid of a microscope.

c. Of the thread-like fibres seen in flowers, some called the *stamens*, are male; the others called the *pistils*, are female. Those on the top of which there is a kind of powder or dust, are the stamens; the others are the pistils.

d. Flowering plants are first classified according to the number of their stamens. These classes are again sub-divided according to the number of the pistils; and the species of the plant is determined by the form of the leaves and other characteristics

e. When the dust from the stamens falls upon the pistil, then the plant bears seed, but not otherwise. Hence, if the stamens of the blossom be removed, no fruit will be produced. But if, after the removal of the stamens from a flower, the dust from the stamens of a plant of a kindred species be sprinkled over the pistil, then the seeds produced will partake of the qualities of both. By this means new varieties of flowers have been produced.

f. In some kinds of trees the flowers on one tree contain stamens only, and on another pistils only. The former may be called male trees, the latter female. The male trees bear no fruit, and are commonly called barren. The reason of their barrenness is obvious from what has been said. The female trees bear fruit when they are planted near the males, as in the case of the date tree and the like.

g. The species of known trees are reckoned at about 50,000; so that our limits preclude any particular description of them. Of the structure of plants we shall treat further under another head—that of Organography.

h. Plants, though they have life, have not the power of locomotion. This distinguishes then from animals. The science that treats of animals is termed Zoology.

SECTION IX.

ZOOLOGY.

i. Animals are regarded first under the following division.

Aphorism XXV.

The animal kingdom is divided into four provinces—viz. the *Vertebrata*, the *Mollusca*, the *Articulata*, and the *Radiata*.

a. The first division, or sub-kingdom, that of the *Vertebrata,* consists of the animals possessing a spine, as man. The second division, that of the *Mollusca,* consists of animals with very soft bodies, many of which have shells, as the snails. The third division, that of the *Articulata,* consists of animals with jointed bodies, like the centipede. The fourth division, that of the *Radiata,* consists of animals whose members are symmetrically disposed around a centre, as in the starfish, the sponge, and the *animalcula,* discernible only by the aid of the microscope, which swarm in stagnant water.

b. Of the first division, the *Vertebrata,* there are four sub-divisions or classes. The first is that of the *Mammalia,* or animals which give suck; the second, of the *Aves,* or Birds; the third, of the *Reptilia,* or Reptiles; and the fourth, of the *Pisces,* or *Fishes.*

c. Of the *Mammalia,* again, there are twelve sub-divisions or orders. The order *Bimana,* or two-handed, includes man alone; the *Quadrumana,* or four-handed, are the monkeys; the *Cheiroptera,* or hand-winged, are the bats. The *Insectivora,* or eaters of insects, include the musk-rat; the *Carnivora,* or eaters of flesh, the tiger; the *Cetacea,* or animals like the whale, the porpoise of the Ganges; the *Pachydermata,* or animals with thick skins, the elephant; the *Ruminantia,* or those that chew the cud, the ox; the *Edentata,* or animals with few or no teeth, the pangolin; the *Rodentia,* or gnawing animals, the mouse; the *Marsupiata,* or animals with a pouch, the Kangaroo; and the *Monotremata,* the Ornithorhyncus, or duck-billed quadruped of Australia.

d. Like the *Vertebrata,* the three other great divisions of the animal kingdom contain many sub-divisions which we do not pro-

pose here to detail.

e. Let us now advert to the structure of plants and animals;—and first of plants.

SECTION X.

ORGANOGRAPHY AND VEGETABLE PHYSIOLOGY.

f. We have spoken of plants and animals as differing from other masses in the circumstance of having *bodies*. A body is defined by Gautama [Book I. Aph. XI.] as the site of organic action, of organs, and of sentiments. It is in consideration of their organic action, and of their having organs appropriate thereto, that we speak of *plants* as having bodies [—B. I. Aph. XI. *d*]. We have no certain evidence that plants have sensations, or sentiments. Let us now consider the order in which a plant is developed from a seed.

Aphorism XXVI.

A seed, being placed in the ground, in due time sends forth two shoots, one ascending and forming the stem, and the other descending and forming the root.

a. When the shoot appears above ground it shows a strong desire—if we may so term it—for light. If the light be excluded, the plant languishes, and the leaves do not acquire their green colour. If light be admitted by a small opening, the plant will incline towards the opening.

Aphorism XXVII.

The food of plants is derived from the earth by the root, and from the air by the leaves.

a. It has been already mentioned that the substance of plants consists chiefly of Oxygen, Hydrogen, and Carbon. Oxygen and Hydrogen may be supplied by water, and every one knows how necessary it is for plants to be furnished with water, which they take in by their roots.

b. From the air plants derive Carbon. Carbon exists in the air, in combination with Oxygen, in the shape of Carbonic Acid gas. This gas is produced in large quantities by the breathing of animals, as well as from other sources.

c. To show that Carbonic Acid exists in the air exhaled from the lungs, breathe, through a tube, into a transparent solution of Lime in water. The lime-water will become turbid, the lime being converted into Carbonate of Lime, or chalk, which is insoluble in water.

Aphorism XXVIII.

The leaves perform for the plant the functions of the stomach and lungs of animals.

a. The stomach of an animal separates the nutritious portions from the food, and rejects the remainder. The leaves of plants do the same. Thus, Carbon being required in a solid shape to form the stem and branches of the plant, it is separated from the Carbonic Acid by the leaves, and the Oxygen of the Carbonic Acid is rejected.

b. So we find that animals exhale a gas which, in a large quantity, is poisonous to animals, but which is necessary to plants; and plants in return inhale this gas, and exhale the Oxygen which is indispensable to animals.

c. We have seen the proof that Carbonic Acid gas is exhaled by animals. Let us now see the proof that Oxygen gas is exhaled by plants.

d. Place a handful of fresh leaves under a large glass vessel quite filled with water and inverted in another vessel of water. Expose the whole to the light of the sun, and the leaves will give out Oxygen, which may be recognised by its chemical properties already described.

e. Of the structure of the flowers of plants, and of the functions of the parts, some account has already been given when treating of that classification of plants (the Linnæan) which is founded on the diversities in the number and arrangement of the stamens and pistils.

f. Let us now consider the structure of the bodies of animals, —and first of the human body.

SECTION XI.

ANATOMY AND PHYSIOLOGY.

Aphorism XXIX.

The parts of the human body are the skeleton, the muscles, the brain, the stomach, the heart, the lungs, the bloodvessels, &c.

a. The skeleton consists of 254 bones. Of these an account will be given in a subsidiary treatise.

b. The muscles constitute the bulk of what is commonly called the flesh. At the impulse of the will these are shortened or

lengthened, and thus they move the bones of the skeleton to which they are attached.

c. The mass of the brain is located in the scull. Its substance, extending downwards through the spinal column, is distributed in small branches, called nerves, to most parts of the body. Where these do not extend, as into the hair or the nails, there is neither sensation nor voluntary motion.

d. The food eaten is divided by the stomach into what is useful and what is not.

e. The digested food [in the shape in which it is called chyle] is carried to the heart by a channel [called the left subclavian vein]. Here it mixes with, and reinforces, the blood, which is the medium by which all the parts of the body, solid or fluid, are supplied with nourishment.

f. From the heart, by its constant action, the blood is forced, through the arteries, into the lungs, and afterwards throughout the body,—returning to the heart through the veins.

g. In the lungs the blood absorbs Oxygen, and parts with Carbon, as has been already noticed when treating of plants,—which, on the contrary, absorb Carbon and part with Oxygen.

h. Having in some manner described the separate portions which constitute the globe, so far as we are acquainted with it, let us advert to the distribution of these constituent portions.

SECTION XII.

GEOGNOSY AND MINERALOGY.

i. Under the head of Geography some account has been given of the arrangement of the earth's surface,—its mountains its rivers, its seas, &c. Now all mountains are not formed of the same materials. Some, as the Himálaya, are formed of very hard rock; and others, as the sandstone range parallel to the Himálaya [—see B. II. Aph. 32.] of softer materials. In some kinds of rocks are found diamonds, &c.; and such useful substances as coal are never found except in company with certain other kinds of rocks. It is obviously desirable both to be able to recognise useful minerals when we see them (—which it is the business of Mineralogy to teach us)—and to know the general arrangement of the mineral masses of the earth, so that we may know where to seek for such minerals as we require, (—and this knowledge constitutes Geognosy).

Aphorism XXX.

Minerals may be divided into two classes, the crystallized and the uncrystallized.

a. The diamond, the topaz, and the emerald, are examples of crystallized minerals. *Kankar*, or nodular limestone, and clay, are examples of uncrystallized minerals.

b. Minerals, when crystallized, can frequently be recognized by mineralogists merely from the form of the crystals.

c. In the case of uncrystallized minerals, we must judge by

means of colour, weight, and other characteristics; but especially by chemical analysis.

Aphorism XXXI.

As an onion is enveloped in many successive coats, so the crust of the earth consists of several successive layers of minerals; but in most places these layers, or *strata*, are rent and disarranged.

a. For example,—in some places the country consists of layers of chalk, &c., level like the mud deposited at the bottom of a pond. In other places these layers appear disarranged and rent by hard rocks, which rise up in the form of mountains. How this has come to pass we shall enquire in the next section [—on Geology].

b. The practical utility of Geognosy is very great. For example, we remarked that the arrangement of the strata of the earth bore a general resemblance to that of the coats of an onion. Now enquirers, by examining the structure of the rocks composing these successive layers, and the fossil remains which belong exclusively to each, have been able to determine the order of superposition which prevails over the whole world, so far as the matter has been yet investigated.

c. If therefore one versed in such enquiries finds, at the surface of the earth in any country, a particular layer, which, to his knowledge, always lies beneath the coal-formation, he can warn the miner not to expend his labour fruitlessly in seeking for coal there.

d. Again, if he find those kinds of rock underneath which coal

is generally found, he may encourage the miner to persevere, when he sees him inclined to give up the search in despair. And so with the other useful substances which the miner obtains from the earth.

e. The proofs of all these assertions cannot be given in so slight a sketch as this; but their verification or refutation would seem an object not unworthy of the labour of the intelligent.

f. It would appear that on various parts of the earth where there is now dry land, the sea formerly flowed; and probably many places are submerged, where there was formerly dry land. No such animals and trees now exist on the face of the earth, as are known to have existed in primeval times.

g. Many of those ancient animals were of very strange kinds. Anatomists can sometimes recognise the species of an animal by means of a single bone; how much more so then, when entire skeletons have been discovered. We shall describe very briefly some of the animals which, from an examination of their skeletons embedded in rocks, have been ascertained to have existed in this globe at the period when those rocks were formed.

h. The Mammoth, the elephant of the ancient world, was about 9 feet high, and above 16 feet long from the point of the nose to the end of the tail. Its tusks were nine feet and a half in length, and were very much curved. Its body was covered with hair.

i. The Megalosaurus, or alligator of the ancient world, was between 40 and 50 feet in length. Its bones are found in England, a country which is now too cold for alligators.

j. The Iguanodon, or gigantic iguana, a kind of long-tailed lizard, grew to above 70 feet long.

k. The Ichthyosaurus, or fish-lizard, must have resembled an alligator with fins instead of feet. The largest species was about 20 feet long. Its eyes were larger than a man's head.

l. The Plesiosaurus differed from the Ichthyosaurus in having a very small head, and a long neck like the body of a serpent.

m. The Pterodactyle, or flying lizard, had a head like a crocodile, and wings like a bat.

n. Now, how did the arrangement of the materials of the earth, which we have been describing [—see Aph. 24 B. II], come to take place? This we proceed to consider—[under the head of Geology—i. e. the *rationale* of the Earth's being as it is].

SECTION XIII.

GEOLOGY.

Aphorism XXXII.

The interior of the earth is probably a mass of ignited matter.

a. If all the earth's heat were derived from the sun, it might be expected that the surface should be the warmest, and that as we dug into the earth we should come to colder portions. But the lower we descend in mines, the higher is the temperature.

b. In many places there are burning mountains, or volca-

noes, which are produced as follows. From the interior of the earth a mass of melted mineral matter makes its way upwards through the upper strata, which it ruptures and forces out of their previously horizontal position. Issuing from the opening thus made, it forms a mountain.

c. In the course of time, clouds assemble on the top of the mountain, and thus streams are produced.

d. By the action of those streams the substance of the mountain is abraded, and quantities of it in powder suspended in the water are carried towards the ocean. Where the current, on meeting the ocean, is stayed, there the matter which the waters in motion had kept suspended, is deposited; and an island is gradually formed, which divides the mouth of the river into two.

e. In each of these the same process is repeated. An island formed in each mouth again doubles the number of mouths, and thus the mouths of the river sometimes become very numerous.

f. It was in this way that the hundred mouths of the Ganges were formed, and the adjoining region called the *Sundarbans*.

g. In each of the islands thus produced, many trees spring up, and the bones of animals accumulate there, whilst numerous shells may be found along their shores.

h. If a volcano should now break forth in such a place, the region would be elevated, and shells and other marine productions would be found on the high grounds, as they are found on the tops of many mountains at this day.

i. It is in no short space of time that all this takes place; therefore man, whose days are few, cannot observe the process

from first to last; but as, after viewing trees of all sizes in a forest, we feel sure that the large trees once resembled the little ones, and that the little ones are imperceptibly growing up to be like the large ones, so, by observing such processes on a small scale, as at the mouths of small streams, where small islands, containing various things floated down are formed and ever altering, we come to the conclusion that similar geological phenomena on a far larger scale must be due to similar causes.

j. As the strata of the Sundarbans, if elevated by subterraneous fire, would be found to contain many bones and complete skeletons of tigers, deer, crocodiles, and other such animals as had been accustomed to frequent that region, so, in the strata which have been formed in other places in very ancient times, we might expect to find the remains of the animals that then lived. And this is the case; as was shown in the preceding section.

k. As the matters that we have been considering are not all ascertainable by the evidence of Sense alone, it is time that we turn to the consideration of the second species of evidence,—viz. that of Inference.

END OF THE THIRD BOOK.

॥ श्री परमेश्वरो जयति ॥

। अथ द्वितीयाध्यायः ।

—oo—

सङ्ख्यापरिमाणयोस्तदाश्रयद्रव्यविचारनैरपेक्ष्येणेह विचारः करिष्यते । अत्र हेतुः पूर्वप्रकरणान्ते प्रदर्शितः ॥

अत्र निर्दिष्टसंख्याविचारविषयं शास्त्रं व्यक्तगणितमित्युच्यते ॥

दशमान्तसंख्याव्यवहारबीजमाह ॥

संख्या दशावधि वर्धन्ते मनुष्याणां दशाङ्गुलित्वात् ॥ १ ॥

क

यदा सजातीयानां समूहो विलोक्यते यथा मनुष्याणां तत्संख्यायाः स्मरणं चिकीर्ष्यते चेत्तर्हि तत्र सङ्केतार्थमङ्गुलीः प्रयोजयेत् । एकैकमनुष्यायैकैकामङ्गुलीमुत्थाप्य तस्याः संज्ञां क्रमेण एकद्यादिकां कुर्यात् । अन्तिमाङ्गुल्युत्थापनानन्तरं पुनः प्रथमाङ्गुल्युत्थापनप्रसङ्गः स्यात् सच यावद्वारं भवेत् तज्ज्ञापनायोपायः प्रकल्प्यः । रूढस्य संख्याकरणप्रकारस्योत्पत्तिः कदाचिदेवमेव स्यात् यतो ऽचाङ्गुष्टद्विर्दशावधिर्भवति । यदि मनुष्याङ्गुल्यो द्वादश भवेयुस्तर्ह्यङ्गुष्टद्विर्द्वादशावधिर्भवेत् ॥

गणितसम्बन्धिनो विधयो बापूदेवकृतगणितप्रकरणादवगन्तव्याः ॥

यदातिमहत्योः संख्ययोर्गुणनं भजनं वा विधेयं तदा सामान्यरीत्या तत्सम्पादने महागौरवं क्लेशश्च भवति अतस्तयोः संख्ययोः तथा अन्ये संख्ये कल्प्येते याभ्यां फलं अल्पक्लेशेन लघुप्रकारेण ज्ञायते येच घात-

प्रमापकसंज्ञे स्याताम् । अथ घातप्रमापकाख्यसंख्या-विशेषाः ॥

ययोः संख्ययोर्गुणनफलं भजनफलं वा ज्ञातव्यं तयोर्घातप्रमापकयोर्योगादन्तराद्वा झटिति सारण्यां गुणनफलं भजनफलं वा लभ्यते एवमिष्टघाततन्मूले अपि ॥ २ ॥

यत्रोत्तरोत्तरमेकयैव संख्ययाधिकाः संख्या वर्त्तन्ते यत्रचाद्यसंख्या चयतुल्या स्यात् तादृश्येका संख्यानां श्रेणी कल्प्या । यथा । १ । २ । ३ । ४ । ५ । इत्यादि । अत्र चयः । १ । ततो द्वितीयैका संख्यानां श्रेणी तथा कल्प्या यथा तत्र संख्या उत्तरोत्तरं द्व्यादिगुणाः स्युर्यत्र चाद्यसंख्या गुणतुल्या स्यात् । यथा । १० । १०० । १००० । १०००० । इत्यादि । अथैर्य श्रेणी प्रथमश्रेण्या अधस्तात् क्रमेण लिख्यते ॥

१	२	३	४
१०	१००	१०००	१००००
५	६	७
१०००००	१०००००	१००००००

अत्रोर्ध्वपंक्तिस्थाः संख्याः क्रमेणाधस्थितसंख्यानां घातप्रमापकसंज्ञाः स्युः । तत्रेदमवगम्यते । तथाहि ॥

ऊर्ध्वपंक्त्यां द्वयोः संख्ययोर्योगो यत्र स्यात्तदधस्ताद्द्वितीयपंक्त्यां स्थिता संख्या द्वितीयपंक्तिस्थयोः तद्योज्ययोजकाधरसंख्ययोर्वधेन समो भवतीति । यथा । ऊर्ध्वपंक्त्यां । २ । ४ । अनयोर्योगः । ६ । एतदधो द्वितीयपंक्त्यां वर्त्तमाना । १००००० । इयं संख्या । २ । ४ । एतदधरयोर्द्वितीयपंक्तिस्थयोः । १०० । । १०००० । अनयोः संख्ययोर्वधेन समाना ॥

एवमेव उपरितनपंक्त्यां संख्ययोरन्तरं यत्र स्यात् त-

दधस्ताद्द्वितीयपंक्त्यां स्थिता संख्या द्वितीयपंक्तिस्थयोः तद्वियोज्यवियोजकाधरसंख्ययोः लब्धा समा भवति यथा । ६ । ४ । अनयोरन्तरम् । २ । एतदधोऽधरपंक्त्यां स्थिता । १०० । इयं संख्या । ६ । ४ । एतदधरयोः द्वितीयपंक्तिस्थयोः । १००००० । १०००० । अनयोः संख्ययोः लब्धा समा भवतीति ॥

एवमेवोपरितनी संख्या द्विच्यादिभिर्गुणिता भक्ता वा ऊर्ध्वपंक्त्यां यच्च भवेत् तदधःस्था संख्या तदुपरितनसंख्याधःस्थसंख्याया द्विच्यादिसंख्यापूर्वको घातो द्विच्यादिसंख्यापूर्वकघातमूलं वा स्यात् । यथा ऊर्ध्वपंक्त्यां । २ । इयं त्रिभिर्गुणिता । ६ । एतदधःस्था । १००००० । इयं संख्या । २ । एतदधःस्थाया । १०० । अस्या घनो भवतीति । अथैकाद्ययुतान्तसंख्यानां घातंप्रमापकाः सारण्यां लिख्यन्ते तेभ्यो यस्याः कस्याश्चिदपि संख्याया घातप्रमापको ऽल्पायासेन लभ्यते ॥

लाघवार्थं चिह्नव्यवहारः ॥ ३ ॥

चिह्नव्यवहार इति । गणिते लाघवार्थं अनेकानि चिह्नानि व्यवहृतानि भवन्ति । अङ्कयोर्मध्ये लिखितं (+) इदं चिह्नं तद्योगज्ञापकं कल्पितम् । यथा २+४ इत्येतेन द्विचतुर्योगः क्रियतामिति ज्ञाप्यते ॥

तिर्यक्सरलरेखाद्वयं समत्वबोधकं कल्पितं । यथा २+४=६ इत्यत्र द्विचतुर्योगफलं षड्भिः सममिति बोध्यते ॥

संख्ययोर्मध्ये (—) एवं तिर्यग्रेखा आद्याया द्वितीया शोध्येति द्योतयति । यथा ६—२=४ इत्यनेन षड्भ्यो द्वयोः शोधितयोः शेषं चतुर्भिः सममिति द्योत्यते । अपिच षड्भ्यो द्वयस्य वर्जनेनैव चत्वारः शिष्यन्ते नान्यसंख्यावर्जनेनेत्यतोऽयं धर्मः सर्वसंख्याविषयको नास्ति । परन्तु कतिचिद्धर्माः सर्वसंख्याविषयका भवन्ति । यथा द्वौ पञ्चानयोर्योगः सप्त । ७ । अन्तरंच त्रयम् । ३ । तद्योगान्तरयोर्योजनेन दशोत्पद्यन्ते एते निर्दिष्टसंख्ययोर्महत्या द्विगुणा भवन्ति । पुनस्तद्यो-

गादन्तरे शोधिते चतुष्कमवशिष्यते इदमल्पसंख्याया द्विगुणं भवति । इत्थं सर्वत्र विद्यात् ॥

तथाहि । द्वौ मुद्रासञ्चयौ वस्त्रबद्धौ कल्प्येतां यत्र मुद्रासंख्या न ज्ञायते । तत्र वस्त्रबद्धसञ्चययोर्यो भेदः तेन सहितः तयोर्योगो बहुमुद्रासञ्चयाद्विगुणो भवति तेन च रहितस्तयोर्योगो ऽल्पमुद्रासञ्चयाद्विगुणो भवतीति निश्चीयते ॥

अथ बहुमुद्रासञ्चयश्चेत् (अ) कारेण द्योत्यते अल्पमुद्रासञ्चयश्च (क) कारेण तदेदं समीकरणरूपमुत्पद्यते ॥

$$(अ+क)+(अ-क)=२अ$$

$$(अ+क)-(अ-क)=२क$$

अत्र अ क अनयोरिष्टसंख्याभ्यामुत्थापितयोरपि पक्षयोः साम्याविघात एव स्यात् ॥

एवमज्ञातसंख्यावगमकविधिकथनाय य ईदृशो वर्ण-

व्यवहारः स बीजगणितसंज्ञको भवेत् ॥

बीजगणिते फलमव्यक्तम् ॥ ४ ॥

पूर्वोक्तचिह्नेभ्यो ऽन्यान्यपि क्रियाद्योतकचिह्नानि भवन्ति । तथाहि संख्ययोर्मध्ये लिखितं (×) इदं चिह्नं तयोर्वधं द्योतयति । यथा अ × ब इदं अकारद्योत्यसंख्या बकारद्योत्यसंख्यया गुणनीयेति द्योतयति । अथाव्यवहितचिह्नौ सन्निहितवर्णावपि स्ववधं द्योतयतः । यथा (अक) अच चेत् अ = २ क = ३ तदा अक = ६ ॥

अथैकवर्णस्याधो रेखां कृत्वा तदधस्तादपरवर्णे लिखिते यत्सम्पद्यते तदुपरितनवर्णद्योत्यसंख्याया अधस्तनवर्णद्योत्यसंख्यया लब्धं द्योतयति । यथा यदि अ = ६ क = २ तदा $\frac{\text{अ}}{\text{क}}$ = ३ ॥

संख्या स्वीयगुणा यथा अ × अ इयमेवं लिख्यते $\text{अ}^{२}$ । इदं अकारस्य वर्ग उच्यते ॥

अथ यदा स्वगुणा संख्या पुनस्तयैव हन्यते यथा अ× अ×अ तदेदं अ३ एवं लिख्यते । इदं अकारस्य घन इत्युच्यते ॥

अथायमुपरिलिखितो ऽङ्को ऽङ्को घातमापकशब्देन व्यवह्रियते ॥

बीजक्रियया सम्पन्नानां फलानां संख्यामात्रसाधारणत्वात् तान्येव व्यक्ते सूत्रत्वेन परिणमन्ते ॥ ५ ॥

उदाहरणे । यदा चतसृषु संख्यासु द्वितीया प्रथमायां तावद्वारं वर्तते यावद्वारं चतुर्थी तृतीयायां तदा तात्श्चतस्रो ऽनुपातस्थाः स्युः । यथा (अ क ग घ) एतासु चतसृषु (अ) अस्यां (क) इयं यावद्वारं वर्तते तावद्वारं चेत् (ग) अस्यां (घ) इयं स्यात् तदैता अनुपातस्थाः स्युः । कल्यतां तावत् (अ) अस्यां (क)

इदं विचारं स्यात्तदा $\frac{अ}{क}=\frac{३}{१}$ । अथच $\frac{ग}{घ}=\frac{३}{१}$ । अथ यावन्तः पदार्थाः प्रत्येकं एकेनैव केनचित्समास्ते सर्वे मिथः समानाइति सिद्धमतः $\frac{अ}{क}=\frac{ग}{घ}$ ॥

अथच समयोः समगुणने समतैवेत्यतिरोहितमतः (क+घ) अनेन पूर्वसमीकरणपक्षयोर्गुणितयोः सिद्धं (अघ=कग) । अनेनानुपातस्थेषु चतुर्षु राशिषु प्रथमचतुर्थयोर्वधो द्वितीयतृतीययोर्वधेन समानो भवतीति ज्ञायते । इदमेव महोपकारकस्य त्रैराशिकाख्यगणितस्य बीजम् । त्रैराशिके अनुपातस्थांस्त्रीन् राशीन् निर्दिश्य चतुर्थो जिज्ञास्यते । तदा प्रश्नालापानुसारेण तान् यथास्थानं विन्यस्य द्वितीयतृतीययोर्वधः क्रियते । अथ स प्रथमचतुर्थयोर्वधेन तुल्य इति चतुर्थराशेरवगमाय स वधः प्रथमेन हियते ॥

कतिचन क्षेत्रमानविषया हि बीज-
गणितमन्तरेण नैव ज्ञायन्ते ॥ ६ ॥

तद्यथा । यद्यङ्गुलमिता रेखा एकसंज्ञिका कल्प्येत तर्हि अङ्गुलद्वयमिता द्विसंज्ञिका स्यात् । अष्टाङ्गुलपरिमिता अष्टसंज्ञा स्यात् । अपिच या संख्या अकारेण ज्ञाप्यते तन्मिता रेखापि अकारेण द्योत्या स्यात् । तथा वर्ग चैचाणि घनचैचाणिच वर्णैर्ज्ञापयितुं शक्यन्ते । ततो बीजगणितक्रियया तद्वर्त्तिगुणा आविर्भवन्ति ॥

आकारस्थानेके गुणा न कदाचिदपि अंकैर्ज्ञापयितुं शक्यन्ते । यथा तुल्यद्विबाहुकचिभुजस्य भूलम्बकोणयोर्मिथः सम्बन्धः । अत्र रेखा सरला वक्राश्च भवन्ति । एतद्विषयिणी विद्या चेचमितिसंज्ञिका स्यात् । अथ सरलवक्ररेखालक्षणार्थं सूत्रम् ॥

या रेखा एकामेव दिशं गच्छेत् सा सरला
याच प्रतिपदं भिन्नदिशं गच्छेत् येन तत्-

त्यौ यौ कौचनासन्नौ बिन्दू सरलरेखायां
न भवेतां सा वक्रा ॥ ७ ॥

अतः सरलवक्ररेखयोर्बिन्द्वोरेकचस्थितयोस्तदव्यवहितोत्तरबिन्दू न कदाचिदेकच स्थातुं शक्नुतः । युक्तीदसंज्ञकस्य चेचमित्यां श्रीबापूदेवशास्त्रिणा संस्कृतेन रचितायां वृत्तपरिधिरूपिण्येव वक्रा व्यवहृता नान्या ॥

युक्तीदानुमानमूलमिदं । ये चेचे मिथः संयुक्ते सर्वतोभावेन परस्परं मिलतस्ते मिथः समाने इति ॥

यथा । प्रथमाध्यायस्य चतुर्थप्रतिज्ञेयम् । ययोस्त्रिभुजयोरेकस्य भुजद्वयतदन्तर्गतकोणौ क्रमेणापरस्य भुजद्वयतदन्तर्गतकोणाभ्यां समानौ तौ मिथः समाने इति । अच त्रिभुजयोर्मिथः संयोजितयोस्ते सर्वतोभावेन मिथो मिलेतामित्यनुमीयते ॥

अच संशयः । यतः सरलवक्ररेखयोर्बिन्द्वोरेकच-

स्थितयोस्तदव्यवहितोत्तरविन्दू न कदाचिदेकत्र स्थातुं शक्नुत इत्युक्तमतो यस्य क्षेत्रस्य मर्यादाः वक्राः सन्ति यस्यच सरलास्तयोः परस्परं सर्वतोभावेन मेलनं न केनचिदपि विभागकल्पनेन सम्भवनीयम् ॥

भूगोलादिगणितसम्बन्धिविद्यानां वर्द्धनार्थं वक्ररेखाद्यतक्षेत्राणां सरलरेखाद्यतक्षेत्रैः साम्यं कर्तुं युक्लीदाख्यस्य कालात् न्यूटणाख्यस्य कालपर्यन्तं द्विसहस्रवर्षेषु अनेके उपकारकाः प्रकाराः कल्पिताः ॥

न्यूटणाख्यस्य प्रकारो लैब्निित्साख्यस्य जेर्मणीदेशीयमहाज्ञानिनो लेखनप्रकारेण परिष्कृतो ऽपरेषां लोपस्य कारणम्बभूव । स वैलक्षण्यपूरितगणितसंज्ञकः स्यात् ॥

स्तम्भोपरि स्थितो मयूरः स्तम्भतले स्थितं विलमागच्छन्तं स्तम्भात्किञ्चिदन्तरे सर्पं दृष्ट्वा तद्ग्राहार्थं तदुपर्यपतत् । तच स्तम्भोच्चयं विलसर्पान्तरंच निर्दिष्टम् ।

सर्पमयूरयोः समकालगमनांशप्रमाणेच निर्दिष्टे । तथाच स मयूरो विलात्कियत्यन्तरे सर्पं जग्राहेत्युदाजहार भास्कराचार्यो लीलावत्यां । एतत्प्रश्नोत्तरं वैलक्षणगणितमन्तरेण न सिध्येत् । भास्करस्तु मयूरस्य यावत्सर्पसंयोगं सरलरेखायां गतिं मत्वा तदनुसारेण फलमानीतवान् । परं यदि मयूरः स्वसर्पसंयोगस्थानं पूर्वं ज्ञातुं समर्थः स्यात्तर्ह्येतद् घटेत । मयूरो हि प्रतिक्षणं स्वमार्गं विकरोति अतस्तद्गमनकक्षुप् प्रतिपदं चलेत् । अत एव तद्गमनंचैकस्यां वक्ररेखायां भवेत् । तद्वक्ररेखानिर्णायकोपाया वैलक्षणगणितज्ञेनैव ज्ञातुं शक्यन्ते ॥

अथ वैलक्षणगणितविषये मध्यबीजज्ञज्ञेयमेकं सुगममुदाहरणं कल्प्यते ॥

उच्चप्रदेशाद्भुवमागतः पदार्थः प्रथमेऽसुपादे पादोनैकादशहस्तमितदेशं अतिक्रामति । द्वयोरसुपादयो-

स्तत्रश्चतुर्गुणं । त्रिष्वसुपादेषु नवगुणमेवमग्रेऽपि । एवं यतत्पदार्थातिक्रांतप्रदेशः कालवर्गानुसारं वर्द्धते । अनेनेदं ज्ञायते यदल्पतमकालेऽपि प्रतनवेगः समानो न भवतीति अन्यथा बहुकाले बह्वन्तरं वेगस्य कथं स्यादिति । अथेष्टकाले इष्टसमानगत्यातिक्रान्तं प्रदेशं निश्चित्य सर्वदा तदनुसारेण गमनवेगं गणयन्ति परं यदि यतत्पदार्थस्यासत्तृतीयचरणान्ते संजातो वेगो ज्ञातव्यः स्यात्तदा सोऽवश्यं तत्पूर्वासुपादजातवेगादधिको भवेत्तदुत्तरासुपादजातवेगान्न्यूनः स्यादिति । तदेतदर्थमादौ न्यूटणाख्यकृतपदार्थविज्ञानशास्त्रस्याद्यप्रतिज्ञा उपपाद्यते ॥

मिथः साम्यं यावच्चलतोर्ययोः प्रमाणयोर्भेद उत्तरोत्तरं केनापि निर्दिष्टमानेन निरन्तरं न्यूनो भवेत् ते अन्ते मिथः समाने भवेतामिति ॥ ८ ॥

अत्रोपपत्तिः । यद्यन्ते ते मिथः समाने न स्याता-मित्युच्येत तर्हि तयोर्भेदः भ एतावान्स्यात् । अतो न्यूनो नैव भवेत् । परमेतत्पूर्वकल्पनाविरुद्धमतस्ते अन्ते मिथः समाने न भवेतामिति न किन्तु समाने एव भवेतामित्युपपन्नम् ॥

अथ यदि पतत्पदार्थातिक्रान्तप्रदेशस्य पादोनैकाद-शहस्तमितदेशो मापकः कल्प्येत तदा पतत्पदार्थेन (य) असुपादैर्यावान् देशो ऽतिक्रम्यते स (य) एतदनुसारे-णास्तीति ज्ञायते ॥

अथ(च)अयमतिसूक्ष्मकालमानद्योतकः स्यात्	—ओ
अथच(ओ)स्थानात्पतितः पदार्थः(य)असुपा-	—अ
दैः(अ) स्थानं प्राप्नुयात् (य+च) असुपादैश्च	—क
(क) स्थानं प्राप्नुयात् (य+२च) कालेनच (ग)	—ग
स्थानं गच्छेदित्यादि कल्प्यतां तदा अतिक्रा-	—घ

न्तप्रदेशमानानि वक्ष्यमाणरीत्या ज्ञास्यन्ते । तथा-

हि । ओअ=य^{२} । ओक=(य+च)^{२} । ओग=(य+२च)^{२} इत्यादि । अतः

अक=ओक−ओअ =२यच + च^{२}=(२य + च)च

कग=ओग−ओक =२यच+३च^{२}=(२य+३च)च

गघ=ओघ−ओग =२यच+५च^{२}=(२+५च)च

इत्यादि ॥

अनेनेदं ज्ञायते (च) परिमितकालखण्डेषु क्रमेणाति-क्रान्तप्रदेशाः २य+च २य+३च २य+५च इत्यादीना-मनुसारेण भवन्तीति । अत्र बहुकाले वेगस्य बह्वन्तरं स्यात् परं यथा यथा स्यान्नयस्यान्तरमल्पं भवेत्तथा तथा तत्तत्यवेगयोर्भेदोऽपचीयेत ॥

अतो यथा यथा(च)कालस्य न्यूनत्वं स्यात्तथा तथा प्रागुक्तातिक्रान्तप्रदेशप्रमाणानि अत्यासन्नानि भवेयुस्त-त्प्रदेशान्ताश्चेष्टबिंदुसन्निहितास्युः पतनवेगाश्चाल्पान्तरा भवेयुः ॥

अथात एवान्ते यदा (च)स्य न्यूनता परमा स्यात् अ-

र्थात् (च)स्य मानं शून्यं स्यात्तदा तानि प्रमाणानि अ-पेक्षितप्रमाणेन समानानि भवेयुरिति पूर्वोक्तप्रतिज्ञया सिध्यति ॥

अथ (च)स्य शून्यत्वे तानि सर्वाणि प्रमाणानि (२य) भवेयुरतः (२य)इयं मर्यादा स्यात् । अनेन (य)असु-पादान्ते पतत्पदार्थगम्यदेशः (२य) गुणितपादोनैकादश-हस्तमितो भवेदिति ज्ञायते ॥

यथा । असुपादक्षयान्ते यदा य=३ तदाप्रभृति चे-त्पतनवेगः समानो भवेत्तर्हि उत्तरासुचरणे स पदार्थः सार्द्धचतुःषष्टिहस्तमितदेशं गच्छेत् । यतः २×३×$\frac{४}{४}^{३}$= ६४$\frac{१}{२}$ । परं वस्तुतो वर्द्धमानगतित्वात्स पंचसप्तति हस्तान् गच्छति ॥

अत्र (ओत्र) रेखात्मको राशिः यः क्रमेण वर्द्धते ता-दृशो ऽस्थिरराशिसंज्ञः स्यात् ॥

इहास्थिरराशयः (य) (र) (ल) इत्याद्यैर्वर्णैर्द्योत्यन्ते ।

अथच यैरस्थिरराशेर्मानं विलक्षणं भवति येषां चेष्टसौष्ठवस्यान्ते नास्ति ते (अक) (कग) (गध) इत्यादयः खण्डाः वैलक्षणशब्दवाच्याः ॥

अथ (य) स्य वैलक्षणं $_d$य अनेन द्योत्यते । एवमेव र ल इत्यादीनां वैलक्षणानि क्रमेण $_d$र $_d$ल इत्यादिभिर्द्योत्यन्ते ॥

यस्य पूर्वोदितप्रश्नस्योत्तरं पूर्वोक्तरीत्या ज्ञातं तस्योत्तरं वैलक्षणगणितेनैवं ज्ञायते । यदि (य) समानष्टङ्का विकृतो भवेत्तदा (य)^२ अयं (२य) भवेदिति सिद्धं तदाचेत् (य)^२ स्य वैलक्षणं $_d$य एतत्स्यात् तर्हि (य)^२ स्य वैलक्षणं (२य$_d$य) भवेत् ॥

अथ (२य $_d$य)^२ (य) अनयोर्मेलनेन वैलक्षणज्ञापकोऽयं प्रथमो विधिरुत्पद्यते । यस्य वैलक्षणं ज्ञातव्यं तस्य घातमापकं निरेकं कुर्यात् ततस्तस्मिन् घातमापकेन तत्तत्यस्तंचास्थिरराशेर्वैलक्षणेनच गुणिते ऽभीष्टं वैलक्षणं संपद्यते ॥

अत्र कतिचिदुदाहरणानि प्रदर्श्यन्ते । $d(य^{३})$ अर्थात् $(य^{३})$ अस्य वैलक्षणं $(३य^{२}\,dय)$ एतत्स्यात् । अथच $d(य^{४})=(४य^{३}\,dय)$ । इत्यादि ॥

अत्र वैलक्षणस्थो यो गुणकः स उच्यते वैलक्षणप्रकृतिरिति । यथा । $(४य^{३}\,dय)$ अत्र $(४य^{३})$ वैलक्षणप्रकृतिः स्यात् ॥

यदा कस्यचिदस्थिरराशेर्मानमपरास्थिरराशिमानाधीनं स्यात्तदा स राशिरपरस्य कर्म स्यादित्युच्यते ॥

यथा । वर्गक्षेत्रस्य फलं तद्भुजाधीनमतस्तद्भुजस्य कर्म भवेत् ॥

वैलक्षणगणितं नाम यस्य कस्यापि निर्दिष्टकर्मणो वैलक्षणसाधनम् ॥

एतद्यस्तं पूरितगणितसंज्ञं स्यात् । अर्थान्निर्दिष्टाद्वैलक्षणात्तत्कर्मण आनयनम् ॥

अत एव पूरितं पूर्वोक्तविधिविपर्यासेनोत्पद्यते ।

तथाहि । यस्य पूरितं ज्ञातव्यं तस्य घातमापकं सैकं कुर्यात् ततस्तस्मिन् सैकघातमापकेन तत्त्यास्थिरराशेर्वैलक्षणेनच भक्ते ऽभीष्टं पूरितं संपद्यते ॥

अत्र चेत् (२य dy) इदमुद्दाहियेत तदातः (य^{२}) इदं लभ्यते ॥

अथ $\int$ इदं पूरितचिह्नं भवति । अतः $\int २य\,dy = य^{२}$ ॥

या गणितरीतयः पूर्वं संक्षेपेण निरूपितास्ताभिर्विविधकारणमेलनजनितं विरुद्धबलद्वयनियोजितपिण्डगत्यादिकमेकं कार्यं प्रायो निर्णेतुं शक्यते ॥

तत्र नानाकारणजनितैककार्यनिर्णयार्थं वक्ष्यमाणनियमो ऽवश्यं ज्ञातव्यः । स यथा । यत्र कारणद्वयमेलनादेकं कार्यं तत्र कारणद्वयं प्रत्येकं स्वातन्त्र्येण स्वस्वप्रवृत्तिस्थलीयकार्यादन्यूनानतिरिक्तं कार्यं करोतीति ॥

अयञ्च गतिविद्याया विषयेषु वस्तुत उपलभ्यते ।

गतिविद्याविषयेष्वेककारणगता कार्यशक्तिरन्यकारणेन न प्रतिबध्यते नवा नाश्यते । यथा । एकः पिण्डो यावन्तं दिग्द्वयसम्बन्धिनं प्रदेशं यावता कालेन क्रमोत्पन्नवलद्वयप्रवर्तितो याति तावतैव कालेन तावन्तमेव प्रदेशं विरुद्धदिग्द्वयगमनहेतुना युगपदुत्पन्नेनापि बलेन प्रवर्तितो यातीति ॥

एवञ्च क्रमप्रवृत्तानेककारणोत्पन्नकार्याणि युगपत्प्रवृत्ततत्कारणोत्पन्नकार्येण समानि भवन्तीति नियमो यथा गतिबलयोस्तथान्यत्रापि क्वचिदस्तीति ॥

परन्तु नायं नियमः सार्वत्रिकः यतो बहुधा द्रव्यद्वयसंयोगाज्जायमानं तृतीयं द्रव्यं स्वजनकद्रव्यद्वयगुणापेक्षया ऽत्यन्तविलक्षणगुणं भवति । तद्यथा । पारदधातुर्द्रवरूपः श्वेतवर्णो भवति गन्धकश्च पीतवर्णो भवति अनयोः संयोगादत्यन्तरक्तवर्णो हिङ्गुल उत्पद्यते । एवं रसरहितः सीसकाख्यो धातुरत्यम्लेन शुक्लेन संयुक्तो

मधुररसं विषविशेषं जनयति । उक्तनियमो यत्र नास्ति तत्रत्या निर्जीववस्तुविषयिणी व्यवस्था रसायनशास्त्रस्य विषयो भवति ॥

तत्रादौ रसायनशास्त्रीयव्यवहारसिद्धयेऽनात्मद्रव्याणि विभजते ॥

द्रव्याणि द्वेधा शुद्धमिश्रभेदात् ॥ ९ ॥

मिश्रद्रव्यं यथा पारदगन्धकात्मकं कपिशीर्षकम् ॥

अमिश्रद्रव्यं यथा गन्धको यस्य मिश्रितत्वविनिगमको न ज्ञायते ॥

मिश्रद्रव्याणि अमिश्रद्रव्यात्मकानि असंख्यानि । अमिश्रद्रव्याणि शताद्धाल्किञ्चिदधिकानि । तेषां तावद्भेदा उच्यन्ते ॥

अमिश्रद्रव्याणि द्वेधा धातुरूपाधातुरूपाणिचेति ॥ १० ॥

सुवर्णलोहपारदादिद्रव्याणि धातुरूपाणि । गन्धकादीन्यधातुरूपाणि ॥

अधातुरूपामिश्रद्रव्याणि द्विधा वायुरूपाण्यवायुरूपाणिचेति ॥ ११ ॥

वायुर्नाम स्पर्शवानसाधारणोष्णतां विनाप्यनियतदेशव्यापनशक्तिमान् बह्वनियतसङ्कोचयोग्यश्च द्रव्यविशेषः । उष्णीकृतजलवाष्पमनियतदेशव्यापनशक्तिमद्भवति किन्त्वसाधारणौष्ण्याभावे तद्व्यापनशक्तिर्नश्यतीत्येतावान् तत्र भेदः ॥

वायवः साधारणादिभेदैर्बहुविधाः । तत्र यः प्राणिनां श्वासोच्छ्वासोपयुक्तः स साधारणसंज्ञः । अन्ये च वायुविशेषाः कथ्यन्ते ॥

अमिश्रवायुविशेषाश्चत्वारो भवन्ति ॥ १२ ॥

तेषां नामानि । प्राणप्रदः । जीवान्तकः । ज-
लकरः । हरिश्चेति ॥

प्रथमो वायुविशेषो ऽतः प्राणप्रद उच्यते यतो नहि
तं विना प्राणिनो जीवितुं शक्नुवन्ति । अस्मिन् न क-
श्चन स्वादः नापि गन्धः । अनेन पूर्णस्य काचपात्रस्य
वर्णः नहि साधारणवायुपूर्णकाचपात्रवर्णाद्भिन्नः । क-
स्तर्हि सामान्यवायोः प्राणप्रदस्यच भेद इति चेच्छूय-
ताम् । दाह्यद्रव्याणि प्राणप्रदवायौ अतिशयेन ज्वल-
न्तीत्यस्ति तत्र भेदः ॥

अचिरादुपशमिष्यज्ज्वलने काष्ठखण्डे प्राणप्रदवायौ
धृते तत्काष्ठखण्डं अतिशयेन ज्वलितुं आरभते ॥

अत्र लोहो ऽपि शुष्केन्धनवत् ज्वलति ॥

प्रज्वलमानः प्रकाशदसंज्ञको ऽस्यारम्भकावयवावि-
शेषः प्राणप्रदवायौ प्रक्षिप्तः सूर्यवत्प्रकाशते नचैवं सा-
धारणवायौ ॥

प्राणप्रदवायुं विना प्राणिनो न जीवन्तीत्युक्तं तदनुपपन्नं साधारणवायौ प्राणिजीवनदर्शनादिति चेन्न साधारणवायौ प्राणप्रदवायोः सद्भावात् । नच साधारणवायौ ज्वलनसामग्रीविशिष्टानां लोहादीनां दाहापत्तिस्तद्धेतोः प्राणप्रदवायोः सद्भावादिति वाच्यं तच्चत्यप्राणप्रदवायोर्जीवान्तकवायुना तदीयज्वलनशक्त्युत्कर्षप्रतिबन्धकेन मिश्रितत्वादतिशयितदाहाभावोपपत्तेरिति ॥

एवं द्वितीयो जीवान्तकाख्यो वायुभेदो न गन्धवान्न रसवान्नच काचपाचसम्भृते ऽप्यस्मिन् रूपमुपलभ्यते यथा प्रथमे । कस्तर्ह्यस्य प्रथमाद्विशेष इति चेत् शुद्धे जीवान्तकवायौ प्रक्षिप्तं ज्वलद्द्रव्यमाशु निर्वाणमवतीत्येको विशेषः । अथ साधारणवायुर्यदि जीवान्तकवायुमात्ररूपः स्यात्तर्हि न किञ्चिदपि ज्वलेत् । यदिच प्राणप्रदवायुमात्ररूपस्तर्ह्येकस्फुलिङ्गस्पर्शात्सर्वं भस्मसाद्भवेदिति मैवं साधारणवायोर्निर्णीतपरिमाणवि-

शेषानुसारेणोक्तवायुद्वयमिश्रिततया पूर्वोक्तदोषद्वया-
भावात् ॥

तच्च परिमाणं जीवान्तकवायोश्चत्वारोंऽशाः प्राण-
प्रदवायोरेकोंऽशः साधारणवायुघटको भवतीत्यत्र किं
मानमिति चेत् प्रत्यक्षपरीक्षासहकृतमनुमानमिति ब्रू-
मः । तद्यथा । जलपूर्णे पात्रे ज्वलन्ती वर्त्तिका तथा
स्थाप्या यथा जलोपरि तरेत् ततस्तदुपरि घण्टाकारं
काचपात्रपिधानं तथा स्थापनीयं यथा तस्याधरान्तो जले
किञ्चिन्निमज्जेत । एवं कृते अचिराज्ज्वलनोपकारो-
पचीणशक्तौ प्राणप्रदवायौ विकृते वर्त्तिका निर्वाति ज-
लञ्च तत्पात्रान्तःप्रदेशे बहुपञ्चमभागपर्यन्तमूर्ध्वं याति
तावति प्रदेशे प्राणप्रदवायोरभावञ्चानुमापयतीति ॥

तृतीयोऽपि वायुप्रभेद उक्तवायुद्वयवद्गन्धरसरहितः
काचपात्रसम्भृततादृशायामनुपलभ्यमानरूपश्च । प्रा-
णप्रदवायुना सह तस्य संयोगाज्जलमुत्पद्यते तत्सूच-
नार्थं एतद्वायोः संज्ञा जलकरः स्यात् ॥

दाहविषये ऽयं प्राणप्रदवायोर्विपरीतधर्मो भवति । यदि ज्वलन्ती वर्त्तिका जलकरवायौ क्षिप्यते तदा तस्यामाशु निर्वाणायां जलकरवायुर्दीप्यते ॥

अयञ्च सर्वेष्वद्ययावज्ज्ञातवस्तुषु मध्ये प्रकृष्टलघुर्भवति । अनेन पूर्णः पेशीविशेषः पक्षिगम्यप्रदेशादूर्ध्वं याति । एतद्वायूपष्टब्धेन महत्प्रमाणेन पेशीविशेषेण कतिपयपुरुषसहितो मञ्चविशेषो बहूच्चप्रदेशोपरि नेतुं शक्यते ॥

एवं चतुर्थो वायुभेदो हरिताख्य उक्तेभ्यः शुद्धवायुविशेषेभ्यो बहुभिर्विशेषैर्विशिष्यते । अस्य वर्णो हरित्प्रायो रसगन्धौचात्यन्तोत्कटौ दुःखप्रदौच ॥

वक्ष्यमाणाः कतिचिद्द्रव्यविशेषा एतद्वायुसंयोगमात्रेण ज्वलन्ति । ते यथा । ताम्रस्यातिचिपिटपत्रं प्रकाशदसंज्ञकश्च पारदादिचेति ॥

अयं प्राणिनां जीवननाशको दृच्चजातीनां शोल्लग्रहेतुश्च । अत एव वस्त्रादिशुल्लीकरणे परमोपयोगी ॥

किञ्च रोगिशालाकारागारादिष्वयं वायुर्महत उपकाराय भवति तत्त्यानां रोगवशात् कारणान्तराद्वा पूतिगन्धादिनाशकत्वात् ॥

धातुवाय्वतिरिक्तानि शुद्धद्रव्याणि नव भवन्ति ॥ १३ ॥

एतानि तेषां नामानि । यथा । अङ्गारः । टङ्कोपादानं । अग्निप्रस्तरजनकः । गंधकः । चान्द्रः । प्रकाशदः । पूतः । अरुणः । काचघ्नजनकः ॥

ध्मातकाष्ठस्य दहने जलेन निर्वाणे ऽवशिष्टोऽङ्गारो भवति श्यामवर्णः ॥

टङ्कावयवः कपिशचूर्णविशेषः टङ्कोपादानम् ॥

लोहखण्डाघातादग्निजनकस्य प्रस्तरविशेषस्यावयवभूतः कपिशवर्णश्चूर्णविशेषः अग्निप्रस्तरजनकः ॥

दाह्यः पीतवर्णः सर्वैर्ज्ञातो द्रव्यविशेषः गन्धकः ॥

बहुभिर्धर्मैर्गन्धकतुल्यो ऽतिदुर्मिलो द्रव्यविशेषश्चान्द्रः ॥

सिक्थकसदृशरूपः तमसि प्रकाशः क्वथितजलोष्णतान्यूनोष्णसंयोगेन घर्षणादिना वा दाह्यः घर्षणज्वलनीयदीपशलाकानिर्माणोपयुक्तो द्रव्यविशेषः प्रकाशदः ॥

कृष्णारुणोऽतिदुर्गन्धयुक्तो द्रवद्रव्यविशेषः पूतः ॥

नैसर्गिकभास्वरकृष्णवर्णोऽग्निसंयोगेन बाष्पत्वदशायामरुणवर्णो द्रव्यविशेषोऽरुणः ॥

काचनाशकद्रवद्रव्यावयवत्वेन कल्पितो वस्तुविशेषः काचघ्नजनकः ॥

धातवष्षट्चत्वारिंशत ॥ १४ ॥

तच्च सुवर्णरजतताम्रसीसकादयो धातवः कतिचित् सम्यग्विज्ञाताः कतिचिच्चातिदुर्मिला अनावश्यकनिरू-

षणाश्च । अतो येषां स्वरूपज्ञानमिहावश्यकं त एव धातवोऽत्र निरूप्यन्ते ॥

सुवर्णाधिकगुरूरजतवर्णः गुरुतमाख्यो धातुः ॥

पारदाख्यो धातुस्साधारणोष्णसंयोगे जलवद्द्रवरूपोऽत्यन्तोष्णसंयोगे बाष्परूपोऽतिशीतदेशे तथा घनो यथास्य पत्राणि कर्तुं शक्यन्ते ॥

रङ्गं रजतवर्णं सीसकवन्मृदुच ॥

दस्ताख्यो धातुः सीसकवर्णोऽतितप्ततादृशायां साधारणवायौ दग्धः तूलवद्वायुना सर्वत्र क्षिप्यते ॥

लघुतमाख्यो धातुरत्यन्तलघुत्वात् जले तरति । अयंच जले वर्त्तमानः स्वयमेव ज्वलति ॥

लवणकराख्यो धातुः जले क्षिप्तस्तरति परन्तु न लघुतमवज्ज्वलति ॥

शर्कराकराख्यो धातुर्यस्माच्चूर्णमुत्पद्यते ॥

अथ प्राणप्रदादिभिः शुद्धद्रव्यैर्भूमण्डलोपलब्धानि सर्वाणि निर्मितानि सन्ति ॥

यद्द्रव्यं यद्द्रव्यजन्यं तद्द्रव्यस्य तत्तद्द्रव्यजन्यताबोधक-
पदेन व्यवहारोऽत्यन्तोपकारक इत्यत आह ॥

रसायनशास्त्रे मिश्रद्रव्याणि स्व-
जनकतत्तद्द्रव्योत्पन्नत्वव्यञ्जकसं-
ज्ञया व्यवहर्त्तव्याणि ॥ १५ ॥

उदाहरणे । हरितवायुना सह लवणकराख्यधा-
तुमेलनात् साधारणलवणमुत्पद्यत इत्यत्र शास्त्रे सा-
धारणलवणस्य संज्ञा लवणकरहरितज इति । अ-
र्थात् । लवणकरस्य हरितवायोश्च मेलनाद् लवण-
स्योत्पत्तिरिति ॥

अथ यथोद्देशक्रमं प्राणप्रदवायुमारभ्य अमिश्रद्र-
व्याणां परस्परमेलनकार्याण्युच्यन्ते ॥

साधारणवायौ प्राणप्रदवाय्वंशेन सह जीवान्तका-
ख्यवायोश्चत्वारोंऽशा भवन्तीत्युक्तं । अत्र साधारण-
वायुस्वरूपं कार्यं रासायनिकं नोच्यते यतोहि तयो-

मेलने ऽपि विशेषो नोत्पद्यते । यत्तु प्रत्येकज्ञात-विशेषयोः पदार्थयोर्मेलनादुत्पन्नं कार्यं नानुमानेन ज्ञातुं शक्यते तत्रैव रासायनिकसम्बन्धो भवतीति पूर्वं सूचितम् ॥

जीवान्तकवायुना सह प्राणप्रदस्य मेलनात्तत्तद्वायु-परिमाणभेदानुसारेण पञ्च कार्यविशेषा उत्पद्यन्ते ॥

तेषुचोत्तरोत्तरं एकांशेन प्राणप्रदवाय्वाधिक्यं ज्ञा-तव्यम् । अतस्तेषां वर्णनं क्रियते । तेष्वाद्यो यथा ॥

स जीवान्तकप्राणप्रदयोर्योगो यमुच्छ्वासश्वासक्रियाया विषयीकुर्वन् पुरुषो ऽत्यन्तं हसति कतिपयक्षणपर्यन्त-मुन्मत्त इवच भवति ॥

द्वितीयो यथा ॥

स उक्तवाय्वोर्योगो यो नीरूपः साधारणवायुसंयो-गदशायां प्राणप्रदवायोरधिकं भागमाकर्षति रक्तवर्ण-श्च भवति । अत्रैवाङ्गारः प्रकाशदश्च सबहुज्वालं ज्वल-ति अयंतु न श्वासोच्छ्वासक्रियाविषयो यत उरोवर्त्तिना

साधारणवायुना संयोगकाले पूर्वोक्तं रक्तवर्णं विषस्वभावं वायुविशेषं जनयति ॥

तृतीयो यथा ॥

स उक्तवाय्वोर्योगविशेषो यो महता प्रयत्नेन विना नार्जयितुं शक्यः अस्मिन्प्रकरणे विशेषतस्तस्य निरूपणं नावश्यकम् ॥

चतुर्थो यथा ॥

पूर्वोक्तो रक्तवर्ण उक्तवाय्वोर्योगः यो जलेन संयुक्तस्तचैव लीयते ॥

पञ्चमो यथा ॥

स उक्तवायुद्वययोगो यो जलमिश्रितात्यन्ताम्लरसविशेषस्वरूपो मांसं दहति यस्मिंश्च लोहादिकमपि लीयते ॥

अथ यद्द्रव्यं यद्द्रव्यजन्यं तद्द्रव्यस्य तद्द्रव्यजन्यताबोधकपदेन व्यवहारोऽस्मिन् शास्त्रे कर्त्तव्य इति पूर्वमुक्तं तथा उक्तवायुद्वयमिश्रणजनितानां परस्परमत्यन्तविलक्षणा-

नां द्रव्याणां व्यवहारो मिश्रणावयवानामाधिक्यन्यून-त्वज्ञापकपदेनच कर्त्तव्यः । यथा । द्वितीययोगः प्रथ-मयोगमपेक्ष्याधिकेन प्राणप्रदवायुना विशिष्ट इतिहेतोः स प्राणप्रदवाय्वाधिक्यबोधकपदेन व्यवहर्त्तव्य इति ॥

अथ नानाविधवस्तुसंयोगसम्बन्धिनां विविधधर्मा-णां निरूपणपूर्वकं उक्तविधसंकेतरचनोपायानां नि-रूपणं क्रियते ॥

एतावत्परिमाणेनामुकेनैतावत्परिमाणम-मुकं संयुक्तं भविष्यति न न्यूनाधिकमिति नियमः केषुचिद्द्रव्येषु न दृश्यते ॥ १६ ॥

यथा । एकपलमितं दुग्धं एककर्षमितेन जलेन संयुक्तं भवति एकपलमितं जलंच एककर्षमितेन दुग्धेन संयुक्तं भवति नचाच कश्चिन्नियमो ऽस्तीति ॥

क्वचित्तु न्यूनतायामनियम आ-धिक्येत्ववधिर्भवति ॥ १७ ॥

यथा । अमुकपरिमाणे जले ऽमुकपरिमाणं लवणं लीयते इत्येतस्मिन्विषये लवणस्याधिक्येऽवधिरस्ति नतु न्यूनतायाम् ॥

उक्तं वस्तुसंयोगस्य प्रकारद्वयं न विशेषतो वस्तुतो रसायनशास्त्रस्य विषयो यतः तच्च संयुक्तद्रव्यद्वयस्य असंयोगावस्थायां दृश्यमाना गुणा उत्तरकाले ऽनुवर्त्तन्ते ऽथवा न सर्वथा तेषां अन्यथाभावो भवति ॥

रसायनशास्त्रीयविध्यनुसारेण संयुज्यमानयोरेकजातीयकार्योत्पादकयोः पदार्थयोः संयोगो नियतपरिमाणयोरेव भवति यच्च पुनःसंयुक्ताभ्यां पदार्थाभ्यां नानाजातीयानि मिश्रणफलान्युत्पद्यन्ते तच्च द्वितीयादिमिश्रणे एकद्रव्यस्य प्रथमसंयोगस्थलीयमेव परिमाणं अपरस्यतु प्रथमसंयोगस्थलीयपरिमाणापवर्त्यमेव परिमाणं भवतीति ॥१८॥

यथा। जीवान्तकवायुना सह प्राणप्रदस्य मेलनात् पञ्च मिश्रपदार्था उत्पद्यन्त इत्युक्तम्। तेषु प्रत्येकं जीवान्तकश्चतुर्दशमितो भवति प्राणप्रदश्च क्रमेण। ८। १६। २४। ३२। ४०। एतत्परिमाणो भवति ॥

यत्परिमाणकौ पदार्थौ प्रत्येकं जल-
करवायुना संयुज्येते तत्परिमाण-
कावेव तौ मिथः संयुज्येते ॥ १९ ॥

यथा। जलकरस्यैकेनांशेन हरिद्वायोः पञ्चविंशङ्गागाः संयुज्यन्ते प्राणप्रदवायोश्चाष्टौ। तदा हरिद्वायोः पञ्चविंशङ्गागाः प्राणप्रदस्य। ८। ३२। ४०। ५६। एभिर्भागैः पृथक् संयुज्यन्ते। अथ। ८। ३२। ४०। ५६। एते ऽङ्का अष्टानामव्यवहितापवर्त्तनानि न भवन्ति। अव्यवहितापवर्त्तनाङ्कास्तु। ८। १६। २४।

। ३२ । ४० । ४८ । ५६ । एते भवन्ति । अतः । १६ । २४ । ४८ । एते प्राणप्रदस्य भागा हरिद्वायुना संयुक्ताः केषुचित्पदार्थेषु वर्त्तेरन् ये पदार्था अस्माभिरद्यावधि न ज्ञायन्ते ॥

रसायनविधिना जायमानः संयोगो नियतपरिमाणयोरेव भवतीति नियमदर्शनात् भौतिकपदार्थानां सर्वेऽवयवा दिगादिवन्न विभागयोग्याः अपितु अत्यन्तसूक्ष्मा अशक्यविभागाश्च केचिदवयवास्सन्तीति कल्प्यते तेच परमाणव उच्यन्ते ॥

किञ्च परमाणूनामतिसूक्ष्मत्वेऽपि तेषां सर्वथा महत्त्वराहित्यं न कल्प्यते तच्च द्वितीयाध्याये चत्वारिंशत्तमे सूत्रे विस्तरेण निरूपितम् ॥

अपिच यद्यपि सुवर्णादीनामेकजातीयाः परमाणवो गुरुत्वे महत्त्वेच परस्परं तुल्यरूपाः तथापि ते भिन्नजा-

तीयलोहादिपरमाणुभ्यो गुरुत्वे विलक्षणा एव भवन्तीति ॥

यदा रसायनविधिना संयुक्ताभ्यां पदार्थाभ्यामेकजातीयमेव कार्यमुत्पद्यते तदा तयोरेकस्यैकैकः परमाणुरपरस्यैकैकपरमाणुना संयुज्यते यच्च पदार्थयोर्मेलनाद्बहुजातीयकार्योत्पत्तिस्तत्रैकः परमाणुरेकेन द्वाभ्यां त्रिभिश्चतुर्भिर्वा संयुक्तो भवति ॥

संयुज्यमानपदार्थपरिमाणस्य संख्यया तदीयपरमाणूनां परस्परापेक्षया गुरुलघुभावोऽनुमीयते । तद्यथा । एकमेकपलमितमंपरञ्चाष्टपलमितमिति द्वे संयुक्ते यच्चैकं नवपलमितं कार्यं जनयतो यच्च द्वयोः परमाणवः प्रत्येकमेकैकेन संयुज्यन्ते तच्चैकपलमितद्रव्यस्य परमाणुरष्टपलमितद्रव्यपरमाणोरपेक्षयाष्टगुणितगुरुरिति स्पष्टम् ॥

मुख्यद्रव्यपरमाणूनां परस्परापेक्षगुरुलघुभावस्य स्पष्टीकरणार्थं तदङ्कैस्सह तन्नामानि प्रदर्श्यन्ते ॥

प्राणप्रदः ८	प्रा	ताम्रम् ३२	ता
जीवान्तकः १४	जी	लोहम् २८	लो
जलकरः १	ज	सीसकम् १०४	सी
हरितः ३५	ह	गुरुतमम् ९८	गु
अङ्गारः ६	अ	पारदः १००	पा
टङ्कोपादानम् ११	ट	दरुम् ३२	द
गन्धकः १६	ग	लघुतमम् ४०	लघु
प्रकाशदः ३२	प्र	लवणकरम् २३	ल
सुवर्णम् ९८	सु	शर्कराकरः २०	श
रजतम् ११०	र		

वीजगणित इव रसायनकार्यविचारेऽपि तत्तद्द्रव्याणां सङ्क्षिप्तसङ्केतकरणमुपकारि यथा पूर्वसूच्यां प्रदर्शितम् ॥

तेच सङ्केताः पदार्थद्वयमेलनजनितकार्यगुरुत्वजनकप्रत्येकपदार्थगुरुत्वस्य स्वसन्निहितलिखितसंख्यायोगं

बोधयन्ति यथा प्रा इत्यर्थं प्राणप्रदस्याष्टसंख्येषु भागेषु सङ्केतितो जी इति जीवान्तकस्य चतुर्दशसु ज इतिच जलकरस्यैकस्मिन्नित्यादि ॥

एते एव सङ्केता मिलिताश्चान्तो मिश्रणफलस्य सङ्केता भवन्ति । तद्यथा । ल इति लवणकरस्य त्रयोविंशतिषु भागेषु ह इतिच हरितस्य पञ्चविंशत्सु भागेषु सङ्केतितम् तद्वयमपि ल + ह इतिरूपेण मिलितं सत् अष्टपञ्चाशद्भागान् लवणस्य बोधयति । इयं संख्या लवणपरमाणुगुरुत्वस्य संख्यां बोधयति । एवं सर्वत्र मिश्रणफले परमाणुगुरुत्वसंख्यावगमप्रकारो बोध्यः ॥

अथैवमुक्तप्रकारेण मिश्रणफलसम्बन्धिनः सिद्धान्तानभिधायेदानीं प्राणप्रदजीवान्तकवायुद्वयमिश्रणफलानि निर्णीयन्ते ॥

१	जी+प्रा	२२
२	जी+२प्रा	३०
३	जी+३प्रा	३८
४	जी+४प्रा	४६
५	जी+५प्रा	५४

एषु पञ्चस्वपि मिश्रगणफलेषूक्तसङ्केतेन घटकद्रव्य-परमाणुपरिमाणं ज्ञाप्यते । घटकद्रव्यपरिमाणतज्ज-न्यत्वादिबोधकेनच सङ्केतेन रसायनशास्त्रे व्यवहार इष्टः । अत्रेदमधिकं विचार्यते । तथाहि ॥

उक्तेषु प्राणप्रदजीवान्तकयोर्मिश्रगणफलेषु कानिचि-दम्लरूपाणि कानिचित्तु न तथा । अथायमवश्य-निरूपणीयो भेदः स्वबोधिकां संज्ञामपेक्षत इत्याह ॥

अम्लानम्लरूपताबोधकैस्सङ्केतैर्मिश्र-
गणफलानां व्यवहारः कर्त्तव्यः ॥ १९ ॥

जीवान्तकप्राणप्रदमिश्रगणफलेषु चोणि अनम्लरू-पाणि अतस्तेषूत्तरोत्तरं केवलं प्राणप्रदपरिमाणाधि-क्यबोधकसङ्केतेन व्यवहारः क्रियते यथा ॥

जीवान्तकस्य	प्रथमप्राणप्रदानम्लविकारः	।
जीवान्तकस्य	द्वितीयप्राणप्रदानम्लविकारः	।
जीवान्तकस्य	परमप्राणप्रदानम्लविकारः	।

उक्तवायुद्वयमिश्रणफलेषु द्वे अम्लरूपे । तयोः सङ्केतायेदमारभ्यते । तथाहि । प्राणप्रदवायुना संयुक्तं द्रव्यं यदैकजातीयमम्लमारभते तदा सोऽम्लः ठन्प्रत्ययान्तेन पदेन व्यवहर्त्तव्यः । यदाच उक्तद्रव्येण द्विजातीयौ अम्लौ उत्पाद्येते तदा तयोर्मध्येऽधिकप्राणप्रदविशिष्टोऽम्लः ठन्प्रत्ययान्तेन न्यूनप्राणप्रदविशिष्टोऽम्लश्च यप्रत्ययान्तेन व्यवहर्त्तव्य इति तृतीयपञ्चमौ च पूर्वोक्तवायुमिश्रणफलभेदावम्लरूपौ क्रमेण न्यूनाधिकप्राणप्रदविशिष्टौचातस्तयोर्जीवान्तक्यो जीवान्तकिकश्चेति संज्ञाद्वयं क्रमेण स्यात् । एवंच पञ्चानामपि वायुमिश्रणफलानामिमाः संज्ञाः ॥

तथाहि ॥

। १ ।	जीवान्तकस्य प्रथमप्राणप्रदानम्लविकारः ।
। २ ।	जीवान्तकस्य द्वितीयप्राणप्रदानम्लविकारः ।
। ३ ।	जीवान्तक्योऽम्लः ।
। ४ ।	जीवान्तकस्य परमप्राणप्रदानम्लविकारः ।
। ५ ।	जीवान्तकिको ऽम्ल इति ॥

एवं जीवान्तकप्राणप्रदनामकस्य प्रथमतत्त्वद्वयस्य परस्परमिश्रणफलानि निरूप्य इदानीं जलकरसंज्ञकेन तृतीयेन तत्त्वेन सह उक्ततत्त्वद्वयस्य प्रत्येकं मिश्रणफलानि निरूप्यन्ते ॥

जलकरः प्राणप्रदश्च प्रतिपरमाणु संयुक्तौ जलं जनयतः । अस्योत्पत्तिर्वक्ष्यते । अस्य मिश्रणफलस्य सङ्केतो ज + प्रा इति । पर्ववत जलपरमाणुगुरुत्वंच नवसंख्याकं ज्ञेयम् ॥

जलकरो जीवान्तकेन संयुक्तो नवसागराख्यजनकं उग्रगंधं वायुविशेषं जनयति यः स्वभावतो ऽनुरागप्रेरित इव जलेन सह संयुज्य लीयते । अत्र जलकरस्य त्रयः परमाणव एकेन जीवान्तकवायुपरमाणुना सह संयुज्यन्ते अत उक्तवायोस्सङ्केतो ३ ज + जी इति तदीयपरमाणुगरुत्वं च । १७ । सप्तदशसंख्याकं बोध्यम् ॥

हरितवायुनामकं चतुर्थं तत्त्वं प्राणप्रदजीवान्तकज-लकरवायुभिः संयुज्यमानं विविधानि मिश्रणफलानि जनयति । तच्च हरितजलकरवाय्वोः संयोगफलमिदानीं निरूप्यते तच्चोग्रगन्धं वायुस्वरूपं जलकरहरितकं अम्लं अनुरागप्रेरितमिव स्वभावतो जलेन संयुज्य लीयते । अस्य संचिप्तसंकेतश्च ज + ह इति एतद्दीयपरमाणु गुरुत्वंच षट्चिंशत्संख्याकं बोध्यम् ॥

पूर्वं एकादशसूत्रे अधातुरूपाण्यमिश्रद्रव्याणि वाय्ववायुभेदेन द्वेधा विभक्तानि । तच्च चतुर्णां अमिश्रवायुभेदानां प्रत्येकं परस्परमिश्रणफलानि निरूपितानि । इदानीं क्रमप्राप्तानामवायुरूपाणामिश्रद्रव्याणां मिश्रणफलानि निरूप्यन्ते ॥

तच्च प्रथमोऽङ्गारः । अयं प्राणप्रदवायुना संयुक्तोऽङ्गारिकं अम्लं प्राणिप्राणहरं वायुविशेषमुत्पादयति । अयंच गुरुत्वाज्जलवत्यावात्यावान्तरे निर्गमयितुं श-

क्यते । अत एव यचायं क्वचिद्गिरिगुहाप्रदेशे स्वभावतो वर्त्तते तस्याधः प्रदेशे एव वर्त्तते नतूर्ध्वभागे तचच स्वादिः प्राणी अनुच्चत्वान्म्रियते मनुष्यादिजातिस्तूच्चत्वान्न प्राणं त्यजति । अस्याङ्गारिकाम्लस्य संचिप्तसंकेतो अं + प्रा इति एतदीयपरमाणुगुरुत्वं च द्वाविंशत् संख्याकं भवति प्राणप्रदवायौ ज्वलिताङ्गारादाङ्गारिकाम्लोत्पत्तेर्हीरकोऽङ्गारारब्ध इति निश्चीयते ॥

अङ्गारो जीवान्तकवायुसंयुक्तो ज्वलनशक्तिमन्तं विचित्रगंधं जीवान्तकाङ्गारजाख्यं वायुविशेषं जनयति ॥

अङ्गारो जलकरसंयुक्तो ज्वलनशक्तिमंतं जलकराङ्गारजाख्यं वायुविशेषं जनयति । अयंच क्वचित्तडागस्थपंकोत्सारणादुपलभ्यते । क्वचिच्च पंचनददेशीयज्वालामुखीप्रदेशादौ अयमेव भूविवरात्सदा ज्वलनमहापरिमाणो निर्याति । एतज्जातीय एव वायुविशेषः प्रस्ताराङ्गारेभ्यो निष्कृष्टुं शक्यते एषु दिवसेषु यूरोपप्रदेशे रात्रौ रथ्याप्रकाशनं तया प्रयुज्यतेचेति ॥

गंधकं प्राणप्रदवायोस्त्रिभिः परमाणुभिः संसृष्टं गांधकिकमम्लं वायुरूपं जले लययोग्यं उत्पादयति । तस्य संकेतो गं + प्रा इति परिमाणुपरिमाणश्च चत्वारिंशत्संख्याकं बोध्यमिति ॥

प्रकाशदः प्राणप्रदस्य पञ्चभिः परमाणुभिः संयोगे सति प्राकाशदिकमम्लं जनयति । तस्य सङ्केतः प्र + ५प्रा इति अतस्तदीयपरमाणुगुरुत्वं द्विसप्ततिसंख्याकं ज्ञेयम् ॥

प्रकाशदो जलकरसंयुक्तः साधारणवायौ स्वतो ज्वलनस्वभा वायुविशेषं जनयति । अयञ्च प्रकाशदस्य जलकरज इति व्यवह्रियते ॥

दशमसूचे अमिश्रद्रव्याणि धात्वधातुभेदेन द्वेधा विभक्तानि । तत्र वाय्ववायुभेदेन द्विविधानामधातुद्रव्याणां मिश्रणफलानि निरूपितानि । इदानीं धातूनां स्वभेदैः सह उक्तद्रव्यैश्च सह मिश्रणफलानि निरूप्यन्ते ॥

लोहादिनानाधातूनां प्राणप्रदेन सह मिश्रणफलं

किट्टमिति लोके व्यवह्रियते । सुवर्णं रजतञ्च प्राण-
प्रदेन संयोगं नेच्छतीव अत एव सुवर्णरजते व्यावहा-
रिकमुद्रादिरचनाय सम्यगुपयुज्येते ॥

लोकप्रसिद्धरक्तिम लोहकिट्टं द्वाभ्यां लोहपरमाणुभ्यां
त्रिभिश्च प्राणप्रदपरमाणुभिरारब्धं भवति । यदि द्व-
योस्त्रयस्तर्ह्येकस्य सार्द्धमिति प्रमाणानुसारेण उक्तलोह-
किट्टं लोहस्य सार्द्धप्राणप्रदजमित्युच्यते अस्य सङ्केतो
२ लो + ३ प्रा इति । अत एव तत्परमाणुगुरुत्वं
चत्वारिंशन्मितंभवतीति । अथ प्राणप्रदलोहयोर-
न्यदेकं मिश्रणफलं लोहस्य प्रथमप्राणप्रदजमितिसंज्ञ-
कमस्ति यचैको लोहपरमाणुरेकेन प्राणप्रदपरमाणुना
संयुज्यते अतस्तस्य सङ्केतो लो + प्रा इति अतश्चास्य
परमाणुगुरुत्वं षट्चिंशन्मितं बोध्यम् । इदञ्च त-
न्मायोगोलाभिघातोत्पतितश्यामलोहमलांशस्वरूपम-
वति ॥

सौसकस्य प्रथमप्राणप्रदजं पीतं भवति द्वितीयप्राण-प्रदजं च रक्तं सिंदूरं इति लोके प्रसिद्धं भवतीति ॥

पारदस्य परमप्राणप्रदजं रक्तवर्णं भवति । पारद-हरितवाव्वोः संयोगाद्वे मिश्रणफले भवतः तच प्रथम-हरितपारदजः श्वेतवर्णश्चूर्णविशेषो महौषधं परम-हरितपारदजं रसकर्पूर इतिलोकप्रसिद्धं महाविषं ॥

पारदधातुर्द्रवरूपः श्वेतवर्णो गन्धकसंयोगादत्यन्त-रक्तवर्णं हिङ्गुलं जनयतीति अष्टमसूचव्याख्यावसाने उक्तं । अच शास्त्रे तत् पारदस्य द्वितीयगन्धकजमिति संज्ञकम्भवति ॥

पारदो ऽनेकैर्धातुभिः सह शीतावस्थायामपि संयु-ज्यते । रजतपाचाणां सुवर्णलेपसिद्धये सुवर्णमिश्रितः पारद उपकरोति ॥

लघुतमं प्राणप्रदसंयोगेन शुक्लवर्णं अतितीक्ष्णरसं द्रव्यविशेषं जनयति इदंच मांसं कर्तयति अस्य संज्ञा लघुतमा इति भवति ॥

लवणकरप्राणप्रदसंयोगफलं लघुतमप्राणप्रदसंयोगे-नात्यन्तसदृशं अस्ति । तस्य सङ्केतो ल+प्रा इति अतो-ऽस्य परमाणुगुरुत्वं एकविंशन्मितं भवति ॥

हरितवायुना सह लवणकरमेलनात्साधारणलवण-मुत्पद्यत इति पूर्वमुक्तं पञ्चदशसूचव्याख्याने । अत्र शास्त्रे तस्य नाम लवणकरस्य हरितज इति । अस्य सङ्केतो ल+ह इति अतोऽस्य परमाणुगुरुत्वं अष्टपञ्चाशन्मितं भवति ॥

शर्कराकरप्राणप्रदसंयोगात् लोकप्रसिद्धाः शर्कराः उत्पद्यन्ते । तस्य सङ्केतः श+प्रा इति अतोऽस्य परमाणु-गुरुत्वं अष्टाविंशतिमितमस्ति ॥

एतावता द्रव्यद्वयारब्धमिश्रणफलानि निर्णीय तद-धिकद्रव्यमिश्रणफलानि अधुना निरूप्यन्ते । विंशति-मसूत्रे ऽम्लानम्लरूपविभागद्वयस्य तदीयाम्लत्वाऽन-म्लत्वबोधकसंज्ञया व्यवहारः कर्त्तव्य इत्युक्तम् । अम्ल इति संज्ञयाऽम्लानामम्लरसवस्त्वरूप एको विशेषधर्मो बोध्यते अन्यश्चाम्लानां विशेषधर्मोऽयं भवति यत्तेषां

क्षुण्णजपादिपुष्परससंयोगजनितनीलिम्ना जलेन संयोगे तज्जलस्य रक्तताऽऽपादनमिति कानिचिदनम्लानि द्रव्यद्वितयमात्रसंयोगफलानि लघुतमावदतितीक्ष्णरसानि सन्ति तानिचोक्तविधजलस्य स्वसंयोगेन हरिततां जनयन्ति । एवंविधैरनम्लविकारैरन्यैश्च धातुप्राणप्रदसंयोगफलैः किट्टैस्संयुक्तान्यम्लानि बहुविधमिश्रणफलजनकानि भवन्ति तन्निरूपणाय सूत्रम् ॥

अम्लानां धातुप्राणप्रदसंयोगफलैः किट्टैः
संयोगाल्लवणविशेषा जायन्ते ॥ २१ ॥

खाद्यलवणसादृश्याल्लवणशब्दोऽत्र लाक्षणिकः लवणविशेषा इति न सर्वा लवणजातिरम्लधातुप्राणप्रदसंयोगफलभूतकिट्टमिश्रणजन्याऽपितु कतिपयलवणजातिरेव यतः खाद्यलवणं हरितलवणकरमिश्रणजन्यं भवति इदञ्च पूर्वमुक्तं । अथैते लवणविशेषा उच्यन्ते ॥

केचिदम्ला इगन्तेन केचिच्च यान्तेन पदेन व्यवहर्तव्या इत्युक्तं अष्टाविंशतितमसूत्रव्याख्याने । तत्रेगन्तपदव्य-

वहृताम्लजनितलवणजातिर्यिदन्तेन यान्तपदव्यवहृताम्लजनितलवणजातिश्चेदन्तेन पदेन व्यवहर्त्तव्या । यथा । जीवान्तकिकाम्लजं लवणं जीवान्तकायितमिति यथाच जीवान्तक्याम्लजं लवणं जीवान्तकितमिति ॥

अम्लानि किट्टैरेव संयुज्यन्ते न धातुमाचेणेतिनियमदर्शनादनेकजातीयकिट्टाम्लमिश्रणजनितातिरिक्तानां लवणानां किट्टजन्यताबोधकपदेन व्यवहारोऽनावश्यकः अतश्च रजतप्राणप्रदजस्य जीवान्तकायितमितिसंज्ञापेक्षया लाघवाद्रजतस्य जीवान्तकायितमित्येव संज्ञा कर्त्तव्या । परन्तु लोहप्रथमप्राणप्रदजस्य गन्धकायिते लोहसार्द्धप्राणप्रदजस्य गन्धकायितेच परस्परभेदज्ञापनाय तत्तत्किट्टजन्यताबोधकसंज्ञया व्यवहारः कर्त्तव्य इति ॥

वक्ष्यमाणायां भागद्वयवत्यां सूच्यां वामभागे अम्लाः किट्टानि तेषां संक्षिप्तसंकेताः परमाणुगुरुत्वञ्च निहितं दक्षिणभागे फलभूतानि लवणानि

फलभूताः संक्षिप्तसंकेताः परमाणुगुरुत्वञ्च निहितमस्ति यथा ॥

लघुतमाया जीवान्तकायितम्

जीवान्तकिकाम्लं=जी+५प्रा=५४ । लघुतमा=ल+प्रा=४८ । } लघुतमाया जीवान्तकायितम्=लप्रा+जी५प्रा=१०२ ॥

अयं लवणविशेषो ऽग्निशस्त्रप्रयोगोपयुक्तचूर्णनिर्माणोपयोगित्वेन लोके प्रसिद्धः ॥

अथ नवसागराख्यजनकस्य जीवान्तकायितम्

जीवान्तकिकाम्लम्=५४ नवसागराख्यजनकम्=३ज+जी=१७ } नवसागराख्यजनकस्य जीवान्तकायितम्=७१ ॥

अयं लवणविशेषो जीवान्तकस्य प्रथमप्राणप्रदजनामकं उन्मादकं पूर्वोक्तं वायुविशेषं जनयति ॥

अथ रजतस्य जीवान्तकायितम्

जीवान्तकिकाम्लम्=५४
रजतस्य प्राणप्रदजम्=
११०+८=११८

रजतस्य जीवान्तकायितम्=१७२ ॥

अयं लवणविशेषश्चिकित्सकैः व्रणोत्पन्नदुर्गंधविनाशाय प्रयुज्यते ॥

अथ लवणकराया गन्धकायितम्

गान्धकिकाम्लम्=ग+
३प्रा=४० ।
लवणकरा=लव+ प्रा
=३१

लवणकराया गन्धकायितम्
=७१ ॥

अयं लवणविशेषो विद्युद्यन्त्रनिर्माणे उपयुज्यते ॥

अथ चूर्णस्य गन्धकायितम्

गान्धकिकाम्लम्
=४० ।
चूर्णम्=श्र+प्रा
=२८

चूर्णस्य गन्धकायितम्
=६८ ॥

अयं लवणविशेषः कटिनीवत् शुक्लवर्णो भवति प्रतिमाविशेषनिर्माणे उपयुज्यते ॥

अथ ताम्रस्य गन्धकायितम्

गान्धकिकाम्लम् =४० ।
ताम्रस्य प्राणप्रदजम् =ता+ प्रा=४०

ताम्रस्य गन्धकायितम् =८० ॥

अयं नीलवर्णो लवणविशेषो विद्युद्यन्त्रनिर्माणे उपयुज्यते ॥

अथ लोहप्रथमप्राणप्रदजस्य गन्धकायितम्

गान्धकिकाम्लम् =४० ।
लोहप्रथप्राणप्रद-जम्=लो+प्रा =३९

लोहप्रथमप्राणप्रदजस्य गन्धकायितम्=७९ ॥

अयं हरिद्वर्णो लवणविशेषः लोके कासीस इति प्रसिद्धः ॥

अथ नवसागराख्यजनकस्य जलकरहरितायितम्

जलकरहरिताम्लम् =३६ । नवसागराख्यजनकः =१७ ॥	नवसागराख्यजनकस्य जलकरहरितायितम् =५३ ॥

अयं लवणविशेषो नवसागरइति प्रसिद्धो जलशीतीकरणादावुपयुक्तः ॥

अथ चूर्णस्याङ्गारिकायितम्

आङ्गारिकाम्लम् =अं+२प्रा= २२ । चूर्णम्=२८ ॥	चूर्णस्याङ्गारिकायितम् =५० ॥

अयं लवणविशेषो लोके कटिनीति प्रसिद्धः ॥

अथ लवणकरायाष्टङ्कोपादानायितम्

टङ्कोपादानिका- म्लम्=८+६ प्रा =६८ । लवणकरा=३१	लवणकरायाष्टङ्कोपादा- नायितम्=९९ ॥

अयं लवणविशेषष्टङ्क इति प्रसिद्धः ॥

अथ चूर्णस्य प्रकाशदायितम्

प्राकाशदकिका- म्लम्=प्र+५ प्रा =७२ । चूर्णम्=२८ ।	चूर्णस्य प्रकाशदा- यितम्=१०० ॥

अयं लवणविशेषो मुख्यो मनुष्याद्यस्थारम्भको-ऽस्ति ॥

एवमुक्तप्रकारेण पूर्वोक्ततत्त्वानामप्रसिद्धान्यापामर-प्रसिद्धानिच मिश्रणफलानि निरूपितानि तत्त्वानेक-द्रव्ययोगादेकद्रव्योत्पत्तिर्वर्णिता । तदर्थं क्रियमाणोऽने-कद्रव्यसंयोगः समासकरणमित्युच्यते । यत्च कस्यचिद्-वयविन आरम्भकद्रव्यजातिनिर्णयाय तदीयावयवानां

विभागः क्रियते तच्च स विभागः समासकरणविपरीतत्वा-
द्व्यासकरणमित्युच्यते । तस्योपायं निरूपयितुमाह ॥

रसायनशास्त्रोक्तानां मिश्रणफलानामवय-
वविभागे त्रयो हेतवः औष्ण्यं विद्युत् व्या-
स्यद्रव्यारम्भकावयवगतपरस्पराकर्षणशक्त्य-
धिकतत्तदन्यतराकर्षणशक्तिमत्पदार्थसान्नि-
ध्यञ्चेति ॥ २२ ॥

तत्रौष्ण्यं यथा पूर्वोक्तं रक्तवर्णं पारदस्य प्राणप्रदजं अग्नितापेन विलीय शुद्धपारदरूपेण शुद्धप्राणप्रदवायु-रूपेणच व्यस्तं भवति ॥

प्राणप्रदवायोः शुद्धस्वरूपप्राप्तयर्थमयमेक उपायो-ऽस्ति यथाचैतत्तथैतद्ग्रन्थव्याख्याने स्फुटीभविष्यति ॥

विद्युद्यथा विद्युत्संयोगेन जलं शुद्धजलकरवायुरूपेण शुद्धप्राणप्रदवायुरूपेण च व्यस्तं भवति । विद्युत्साधन-कव्यासकरणरीतिरेतत्प्रकरणटीकायां प्रदर्शयिष्यते ॥

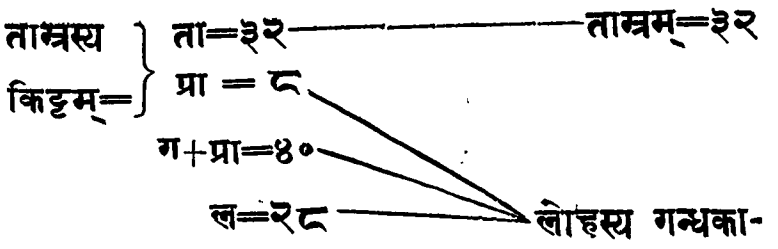
व्यास्यद्रव्येत्यादि । यथा । पूर्वोक्तं तुत्थाख्यं ताम्रस्य गन्धकायितं स्वमिश्रितजले स्वच्छलोहखण्डप्रक्षेपेण व्यसितुं शक्यते । तथाहि । उक्तावस्थायां ताम्रमपेक्ष्य लोहस्याम्लाकर्षणशक्त्याधिक्यादम्लं लोहेन संयुज्यते ताम्रञ्चाम्लेन वियुक्तं सत् लोहपृष्ठमेवाधिरोहति । सकले ताम्रे लोहपत्राधिरूढे लोहांशेषुचाम्लमिश्रितेषु जातेषु तच्च जले काशीशाख्यं लोहस्य गन्धकायितमुपलक्ष्यते नतु ताम्रस्येति ॥

रसायनज्ञैः प्रतिपदार्थं यावन्त आकर्षकाः पदार्थाः प्रत्यक्षपरीक्षणैर्ज्ञायन्ते त एकस्मिंश्चक्रे लिख्यन्ते । तेषु योऽधिकाकर्षकः स आदौ ततो न्यूनाकर्षक इति क्रमो भवति । एतच्चक्रस्यावलोकनेन यस्मिन् कस्मिंश्चित्पदार्थे तद्व्यासकरणार्थं ये ये पदार्थाः प्रक्षेप्यास्ते ज्ञायन्ते ॥

एकोनविंशसूत्रव्याख्याने लिखितायां सूच्यां प्रदर्शिता द्रव्याणां परमाणुगुरुत्वसंख्या तत्तत्तुल्यबलाङ्कशब्देनापि व्यवह्रियते यतस्ते मिश्रपदार्थोत्पादने स्वस्वाङ्क-

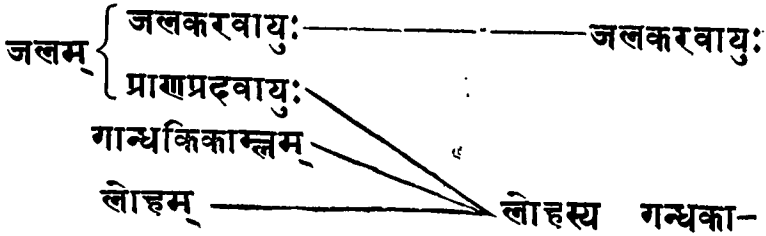
परिमितास्तुल्यबला भवन्ति। यच्च यः पदार्थः स्वाङ्क-परिमितो वर्त्तते तच्चान्योऽपि स्वाङ्कपरिमाणेनैव स्थातुं शक्नोतीत्यर्थः। यथा। पूर्वोदाहृतौ तुत्थस्य व्यासकरणेन चेदेकविंशन्माषमितं ताम्रं पृथग्भवेत्तदा तच्च सप्तविंशतिमाषमितं लोहं संयुज्येत यावत्यम्लरसे एकविंशन्माषमितं ताम्रं लीयते तावति सप्तविंशतिमाषमितमेव लोहं विलीयते नत्वधिकमित्यर्थः। एवं परीक्षणेन ताम्रलोहयोस्तुल्यबले क्रमेणैकविंशत्सप्तविंशत्यंशप्रमाणे भवतः। इत्थं प्रत्यक्षपरीक्षयैव चक्रेऽङ्का लिखिताः। यस्य कस्यापि पदार्थस्य व्यासकरणार्थं निर्मित्यर्थं वा तद्घटनावयवा यावत्प्रमाणा उपयुज्यन्ते तत्प्रमाणानि चक्राङ्कालोकनेन निःशङ्कं ज्ञायन्ते रसायनज्ञैः॥

ताम्रगन्धकायितस्य लोहसंयोगाद् यो विकारो व्यासकरणफलभूतः पूर्वमुक्तः स सङ्क्षिप्तसङ्केतोपायेन प्रकाश्यते। यथा॥



यितम्=ग३प्रा+लप्रा=७६ ॥

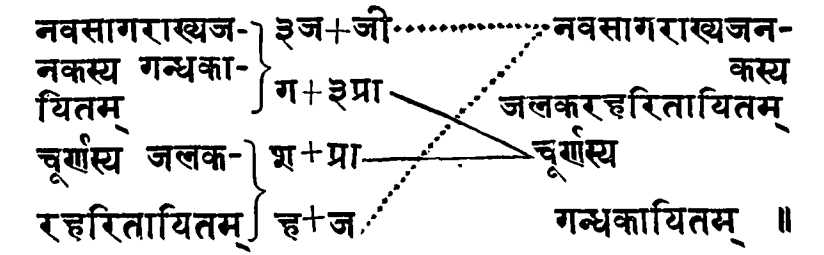
लवणजातिषु सर्वे धातवः किट्टरूपेणैव तिष्ठन्तीत्युक्तं। इदंत्ववधातव्यम् यद्रसायनीयपदार्थानां दर्शिततुल्यबलाङ्कानुसारेण यावानेव ताम्रसम्बन्धी प्राणप्रदो ह्यविंशन्मितं ताम्रं ताम्रगन्धकायिते किट्टतां नयति तावानेवाष्टाविंशतिमितं लोहं किट्टतां प्रापयति परन्तु जलमिश्रितगान्धकिकाम्ले प्रक्षिप्तं लोहं तदम्लेन स्वस्य रसायनीयसंयोगसिद्धये यथोपयोगं जलात्प्राणप्रदमाकृष्य गृह्णाति। अत एकाकी जलकरो बुद्बुदद्वारा निर्याति इदञ्चानन्तरालेखे स्पष्टं यथा ॥



यैरुपायैरेतादृशबुद्बुदरूपः शुद्धजलकरः रचितुं शक्यस्ते उपायाष्टीकायां व्यक्तीकरिष्यन्ते ॥

द्रव्यचयविषयेषूक्तोदाहरणेषु सर्वत्रैकं द्रव्यमपरद्रव्यमाकृष्य तृतीयमुत्सारयतीति समानं क्वचित्तु भिन्नभिन्नद्रव्यचतुष्टयारब्धे द्वे मिश्रणफले परस्परसंयोगदशायां स्वघटकावयवादानप्रतिदाने कुरुतः। यथा चूर्णस्य जलकरहरितायितं यदा जलमिश्रितं सत् तथाविधेन नवसागराख्यजनकस्य गन्धकायितेन संयुज्यते तदा गान्धकिकाम्लं चूर्णेन संयुज्यते जलकरहरितिकाम्लं च गान्धकिकाम्लवियुक्तेन नवसागराख्यजनकेन संयुज्यते। यदाच चूर्णस्य जलकरहरितायितं केवलेन गान्धकिकाम्लेन संयुज्यते तदा तच्च

स्वसंयोगयोग्यद्रव्यान्तरानुपलम्भाद्वायुरूपेण बहिर्निर्यांति। तदिदमालेख्येन प्रदर्श्यते। तच सव्यभागमारभ्य दक्षिणभागस्पर्शिनीभ्यां रेखाभ्यां एकः संयोगः प्रदर्श्यते सव्याद्दक्षिणभागमागच्छता बिन्दुसन्तानेनचापरः संयोगः प्रदर्श्यत इति। तद्यथा ॥



एतावता प्रकरणेन व्यासकरणोत्तरं मानुषशक्तिसाध्यपुनरुत्पत्तयः पदार्था वर्णिताः। यथा। पारदस्य प्राणप्रदजः प्राणप्रदरूपेण पारदरूपेणच यथा व्यस्तः कर्तुं शक्यः तथा पुनरपि प्राणप्रदपारदयोर्मेलनात्पूर्ववत् कर्तुं शक्य इति। केचित्पुनः पदार्था नैतादृशस्वभावाः। यथा। काष्ठखण्डं व्यासकरणोपायैः प्राणप्रदजलकरशुद्धाङ्गारस्वरूपतां नेतुं शक्यते मांसखण्डं वा प्राणप्रदजलकरजीवान्तकशुद्धाङ्गारस्वरूपतां न पुनः

कयाचिदस्मद्युक्त्या पूर्वरूपमिति यत एषां पुनरुत्पादने जीवनशक्तिरसाधारणं कारणं नच सा मानुषशक्तिसाध्येति ॥

जीवनशक्तीरसायनविधीन् प्रतिबध्नात्यन्यथा वा करोति ॥ २३ ॥

भूमौ निक्षिप्तं बीजं मनुष्यशक्त्यसाध्यान् गुणान् वृक्षे जनयति । यथा । मञ्जिष्ठाबीजं लोकोत्तरं वर्णमाम्रबीजं वा लोकोत्तरं रसमुत्पादयति ॥

तदेतस्माद्वेतोर्वनस्पतिविद्याविषयभूतान्वनस्पतिभेदान्निरूपयितुमारभते ॥

अथ वृक्षभेदज्ञापनाय सूत्रम् ॥

वानस्पत्या वनस्पतयश्चेति द्विविधा वृक्षा भवन्ति ॥ २४ ॥

तत्र वनस्पतयोऽपुष्पवन्त उच्छिलीन्ध्रादयः । पुष्पवन्तो वानस्पत्या आम्रादयः ॥

पिप्पलादयो वृक्षा अपुष्पवर्गे न गण्यन्ते यतस्तेषां पुष्पाणि फलान्तर्भागे वर्त्तमानानि सूक्ष्मदर्शकयन्त्रद्वारा दृश्यानि भवन्ति ॥

पुष्पाणां केसरा द्विविधा भवन्ति पौरुषाः स्त्रैणाश्चेति । येषामग्रेषु पुष्परजो वर्त्तते ते पौरुषा अन्ये स्त्रैणा भवन्ति ॥

वानस्पत्येषु समानपौरुषकेसराणां पृथग्वर्गाः क्रियन्ते तेषुच प्रत्येकं समानस्त्रैणकेसराणां वर्गाः पृथक्कल्प्यन्ते पत्राद्याकारादिभिस्तेषां विशेषा निर्णीयन्ते ॥

अथ यदा पौरुषकेसररजांसि स्त्रैणकेसरे पतन्ति तदा बीजमुत्पद्यते नत्वन्यथा । अतो यदि कस्यचित्पुष्पस्य पौरुषकेसरा निष्कास्येरंस्तदा तस्मात्फलं नोत्पत्स्यते । यदि तु कस्यचिद्वृक्षस्य पुष्पात्पौरुषकेसरानपास्य तत्स्त्रैणकेसरे तत्सजातीयान्यवृक्षपुष्पपौरुषकेसरस्य रजः क्षिप्यते तदा तस्मात् तद्वृक्षद्वयगुणविशिष्टं बी-

जमुत्पद्यते। एवं यत्नेनानेके पुष्पविशेषा उत्पाद्यन्ते ॥

अथ कस्मिंश्चित्कस्मिंश्चित्सजातीयवृक्षवर्गे कतिषु-चिद्वृक्षेषु पौरुषकेसरविशिष्टान्येव पुष्पाणि भवन्ति ते पुरुषाख्याः स्युः। अन्येषच्च वृक्षेषु स्त्रैणकेसरविशि-ष्टान्येव पुष्पाणि भवन्ति ते स्त्रीसंज्ञकाः स्युः। तच्च पुरुषाख्या नैव फलन्ति अत एव ते वन्ध्या उच्यन्ते। तेषां वन्ध्यत्वे स्त्रैणकेसराभावः कारणम्भवति। स्त्री-संज्ञकाश्च पुरुषनिकटस्थाः पौरुषकेसररजःसंयोगेन फलन्ति यथा खर्ज्जरादयः ॥

वृक्षविशेषा लक्षसंख्याधिका भवन्ति किमिह तेषां वर्णनेनेत्यलम् ॥

अथ वृक्षावयवसंस्थितिवर्णनं शरीरवर्णनप्रकरणे करिष्यते। वृक्षा जीवनविशिष्टा अपि स्थानान्तरगमनासमर्था इति ते जन्तुभ्यो भिद्यन्ते। अथ जन्तु-वर्णनम् ॥

जन्तुभेदज्ञापनार्थं सूत्रम् ॥

जन्तूनां चत्वारो वर्गा भवन्ति पृष्ठ-
वंशविशिष्टानां कोमलशरीरविशि-
ष्टानां काण्डविशिष्टानां शरीराभि-
तोऽवयववविशिष्टानाञ्चेति ॥ २५ ॥

तत्र प्रथमवर्गजाताः पृष्ठवंशविशिष्टा यथा मनु-
ष्यादयः । द्वितीयवर्गजाता अतिकोमलशरीरविशि-
ष्टाः प्रायः शुक्त्यन्तर्गता भवन्ति यथा शम्बूकादयः ।
तृतीयवर्गजाताः काण्डविशिष्टशरीरा यथा शतपदा-
दयः । चतुर्थवर्गजाता अभितोऽवयववविशिष्टा यथा
जलनीलीव्याप्तसलिले सञ्जाता दृश्या प्रायः सूक्ष्मदर्श-
कयन्त्रेण दृश्या जन्तुविशेषाः ॥

अथ प्रथमवर्गस्य चत्वारो भेदा भवन्ति तत्र प्रथमे
सस्तना द्वितीये पक्षिणस्तृतीये सर्पाश्चतुर्थे मत्स्याः ॥

अथ सस्तनाः पुनर्द्वादशधा भवन्ति । ते यथा द्विहस्ता मनुष्याश्चतुर्हस्ता वानरा हस्ताभ्यां उड्डीयमाना वातुल्यः कीटभोजिनश्छुच्छन्दर्यादयो मांसभोजिनो व्याघ्रादयो जलस्थाः शिशुमारादयः स्थूलचर्म्मिणो गजादयो रोमन्थकरा वृषादयो अदन्ता वज्रकीटादयः कर्तनकरा मूषिकादयः पेशीविशिष्टाः कङ्गरूसंज्ञका जन्तुविशेषाश्चञ्चुविशिष्टाश्चतुष्पदा अस्त्रेलियाख्ये देशे निवसन्ति ॥

अथावशिष्टानां चयाणां वर्गाणां प्रत्येकं बहवो भेदा भवन्ति ते विस्तरभयादिह नोच्यन्ते ॥

अथ जन्तूनां वृक्षाणाञ्च शरीरित्वरूपो धर्मोऽन्यवस्तुभ्यो भेदक इति पूर्वं सूचितं । तत्र जन्तूनां शरीरवत्वं प्रसिद्धं वृक्षाणां शरीरित्वन्तु वृद्ध्यादिरूपचेष्टाहेतुजलाकर्षणकर्तृमूलादिकर्म्मेन्द्रियवत्त्वात् । तदुक्तं गौतमेन । चेष्टेन्द्रियार्थाश्रयः शरीरमिति । चेष्टाया इन्द्रियाणां

सुखदुःखादिरूपार्थानां चाश्रय इत्यर्थः । परन्तु वृक्षाणां ज्ञानेन्द्रियसत्त्वासत्त्वयोर्विनिगमनविरहात्सुखादिमत्त्वं न निश्चितम् । तच्च पूर्वप्रतिज्ञातं वृक्षाद्बीजोत्पत्तिप्रकारमभिधातुमाह ॥

भूमिनिहितं बीजं स्वस्वजातीयाङ्कुरोत्पादानुकूले काले ऊर्ध्वाधोगामिनौ द्वावङ्कुरौ जनयति तत्रोर्ध्वगामिना प्रकाण्डोऽधोगामिनाच मूलमारभ्यते ॥ २६ ॥

भूमध्यान्निर्गच्छन्नवाङ्कुरस्तेजसे स्पृहयतीव यतस्तेजस्संयोगाभावे हरितवर्णरहितपत्रतां प्राप्ता वृक्षजातिर्म्लायते । ययैव दिशा यावतैवावकाशेन तेजस्तत्सन्निधिं प्राप्नोति तामेव दिशं तावतैवावकाशेन वृक्षजातिरपि तेजोऽभिमुखं याति ॥

वृक्षास्वशरीरपुष्टिहेतून् पदार्थान्

मूलेन पृथ्वीतः पत्रैश्च वायोः सकाशादाकृष्य गृह्णन्ति ॥ २७ ॥

प्राणप्रदजलकराङ्गारा वृक्षजातेस्साधारणारम्भका इति पूर्वं सूचितम्। तत्र वृक्षवृद्धिविषये जलसेकस्यात्यावश्यकत्वेन वृक्षैस्स्वमूलाकृष्टजलात्प्राणप्रदजलकरौ प्राप्येते। अङ्गारस्तु वायोः सकाशात्प्राप्यते यतोऽङ्गारः प्राणप्रदमिलितोऽङ्गारिकाम्लवायुविशेषस्वरूपेण साधारणवायौ तिष्ठति सच वायुविशेष उच्छ्वासक्रियया काष्ठादिदहनक्रियया चोत्पद्यते। प्रत्यक्षञ्चात्र प्रमाणम्। तथाहि। काचपात्रान्तर्वर्त्तिनि स्वच्छजलसृष्टे चूर्णजले काचनलिकाद्वारा श्वासवायुः प्रवेश्यतां येन श्वासक्रियाजन्याङ्गारिकाम्लवायुसंयोगवशात्तज्जलान्तर्गतचूर्णं कठिन्यवस्थामागच्छति सति तज्जलं कठिनीमयत्वात् क्षीरवर्णं भविष्यतीति ॥

जन्तूनामुदरफुप्फुसे यत्कार्यं सम्पाद-

यतः तदेव कार्यं वृक्षाणां पत्राणि
सम्पादयन्ति ॥ २८ ॥

यथा जन्तूनामुदरं भुक्तान्नसम्बन्धिनां शरीररक्षा-
सम्पादकानामंशानां अन्तस्सङ्ग्रहेणानुपयुक्तानामंशानां
बहिर्निःसारणेनचोपकारकं भवति तथैव वृक्षाणां पत्रा-
ण्युक्तकार्यसम्पादनेनोपकुर्वन्ति । वृक्षाणां स्तम्बशा-
खाद्युत्पादनायाङ्गार आवश्यकः सच पर्णैराङ्गारिकाम्ल-
वायुसकाशाद्गृह्यते तत्सम्बन्धिप्राणप्रदश्च त्यज्यते ॥

तदेवं जन्तवस्स्वसजातीयापकारकं वृक्षाणामत्युप-
कारकं वायुं निःश्वसन्ति वृक्षा अपि जन्तुनिःश्वसितं
स्वोपकारकं वायुमन्तरादाय जन्तूपकारकं प्राणप्रदवा-
युं बहिर्निःसारयन्तीतिसिद्धम् ॥

आङ्गारिकाम्लवायुर्जन्तुभिर्निःश्वस्यत इत्यत्र पूर्वं युक्ति-
र्दर्शिता इदानीं प्राणप्रदो वृक्षैर्निःश्वस्यत इत्यत्र प्रमाणम्

प्रदर्श्यते। तथाहि। अम्लानपत्रसहितं जलपूर्णं विशालकाचपात्रं जलपूर्णे पात्रान्तरेऽधोमुखं संस्थाप्यातपे स्थाप्यतां ततः पत्रेभ्यः प्राणप्रदवायुर्निर्गमिष्यति तन्निर्गमनलक्षणानिच पूर्वोक्तरसायनप्रकरणप्रतिपादितविध्यनुसारेणावगन्तव्यानीति ॥

वृक्षाणां पुष्पनिर्मितिव्यवस्था तदीयसकलावयवप्रयोजनञ्चेत्येतद्वयं स्त्रीपुंजातीयकेसरानुसारेण वृक्षभेदनिरूपणावसरे संक्षेपेण वर्णितम् ॥

अथेदानीं जन्तुशरीरसंस्थितिर्विविच्यते तत्रादौ मनुष्यशरीरावयवव्यवस्थायां सूत्रम् ॥

अस्थिपञ्जरो मांसरज्जुर्मस्तिष्कमुदरं
हृदयः फुप्फुसं रक्तवहा नाड्य इत्य-
वयवा मनुष्यशरीरस्य ॥ २९ ॥

तत्र चतुःपञ्चाशदधिकद्विशतसङ्ख्याकास्थिसङ्घातोऽस्थिपञ्जरः इदञ्चैतत्प्रकरणव्याख्यायां स्फुटीभविष्यति ॥

मांसस्य मुख्योंऽशो मांसरज्जुः । अस्या आकुञ्चनप्रसारणे इच्छाजनितयत्नेन भवतः ताभ्याञ्चास्थिपञ्जरवर्तीन्यस्थीनि चाल्यन्ते ॥

विशेषतः शिरसि वर्तमानः शुक्लवर्णः स्नेहविशेषो मस्तिष्कं । सूक्ष्मतन्त्वाकारा अस्यांशाः पृष्ठवंशद्वारा प्रसरन्तो नखकेशान्विहाय सर्वान्शरीरावयवान् व्याप्नुवन्ति । अत एव नखकेशावच्छेदेनैच्छिकी क्रिया ज्ञानञ्च नोत्पद्यते ॥

शरीरपुष्ट्युपयुक्तानुपयुक्तावशांशौ येन विभाज्येते तदुदरम् ॥

जीर्णमन्नं सर्वावयवपुष्ट्युत्पादकरुधिरवर्द्धकशुक्लरसस्वरूपेण परिणतं नाडीद्वारा यत्र प्रविशति स हृदयः ॥

सन्ततासङ्कुञ्चनप्रसारणवतो हृदयस्थलान्निर्गत्य यच्च रुधिरं प्रथमं प्राप्नोति तत्फुप्फुसम्। हृदयनिर्गतं रुधिरं यद्द्वारा फुप्फुसं प्रविशति पुनश्च सर्वशरीरे कृतसञ्चारं पुनर्यद्द्वारा हृदयं प्राप्नोति ता नाड्यो रक्तवहा इत्युच्यन्ते ॥

फुप्फुसदेशे रुधिरं प्राणप्रदवायुना संयुज्यते अङ्गारेण वियुज्यतेच एतद्विपरीतस्वभावा दृच्छजातिरङ्गारेण संयुज्यते प्राणप्रदेन वियुज्यतेचेति पूर्वं सूचितम ॥

एतावता भूगोलघटकावयवा यथाज्ञानं निरूपिताः इदानीं तदवयवानां प्राप्तिस्थानानि निरूप्यन्ते ॥

भूपृष्ठस्थनदीसमुद्रपर्वतादयो भूपृष्ठविद्याप्रसङ्गे संक्षेपेण वर्णिताः। तच्च सर्वपर्वतानामारम्भकद्रव्याणि नैकजातीयानि क्वचिद्धिमालयादौ पर्वतेऽतिकठिनानां क्वचिच्च सैकतपाषाणपर्वतादौ मृदीनां शिलानामुपलम्भात। क्षीरकाः प्रस्तराङ्गराश्च सर्वभूमिषु साधारणेन

प्राप्तियोग्या न भवन्ति अपितु तत्प्राप्तिस्थानानि विशेष-लक्षणलक्षितानि सन्ति इत्येतत्सर्वं व्याख्याने स्पष्टीकरिष्यते । पार्थिवविषयभूतानामाकरजपाषाणानामवयवव्यवस्थाज्ञानपूर्वकेणाभीप्सितपाषाणविशेषोपलब्धस्य-लक्षानेन साध्यस्य तज्जातिप्रत्यभिज्ञानस्य सिद्ध्यर्थं पाषाणविद्याया उपक्रमादादौ पाषाणानां भदेप्रदर्शनार्थं सूत्रम् ॥

नियताकारा अनियताकाराश्चेति पार्थिवाः पाषाणा द्विविधा भवन्ति ॥ ३० ॥

नियताकारा हीरकपद्मरागमरकतादयः । अनियताकाराः कर्करस्फटादयः ॥

नियताकारा बहुधाकारदृष्टिमात्रेण एतद्विद्याज्ञानिभिर्निश्चीयन्ते ॥

रूपगुरुत्वादिलिङ्गैरनियताकाराणामभेदा ज्ञायन्ते रसायनशास्त्राभ्यासकरणेनच ॥

यथा पलाण्डुरनेकैस्त्वक्पुटैरावृतो भवति तद्वद्भूरप्यनेकैः पार्थिवांशपुटैरावृता भवति परं तानि पार्थिवांशपुटानि प्रायश्छिन्नभिन्नानि जातानि ॥ ३१ ॥

यथा। पृथिव्यां क्वचित्प्रदेशे कठिनीमयानि भूपुटानि जलाशयतलस्थितपङ्कवत्समपृष्ठानि भवन्ति प्रदेशान्तरे पुनरधरपुटनिर्गच्छच्छिलासमूहभस्मावस्थानतया विषमपृष्ठानि भवन्ति। तत्र यो हेतुः सोऽग्रिमप्रकरणे विचारयिष्यते ॥

अस्त्येतस्या विद्याया लोके महानुपयोगः। तथाहि। एतद्विद्याया ज्ञानिनः प्रत्येकं पार्थिवांशपुटानां निर्मितिं तत्तदर्त्यस्थां दृष्ट्वांशानाञ्च स्थितिं निरीक्ष्य पार्थिवांशपुटस्थितिक्रमं निरूपयन् अत एतद्विद्याविद् यत्पार्थिवांशपुटं स्वनिजाङ्गारपार्थिवांशपुटात्सदा ऽधरेव

वर्तते तत्र खनिजाङ्गारलाभाय खनन्तं मनुजं वीक्ष्य वृक्ष खनिजाङ्गरं मा मृगयस्व तवेह श्रमो वृथा स्यादिति तं कथयित्वा तस्य निष्फलदुःखं दूरीकुर्यात् पुनर्यदि तादृशं पार्थिवांशपुटं पश्येद्यदधस्तात्खनिजाङ्गरो वर्तते तर्हि तत्र खननार्थं खनिजाङ्गारान्वेषणमचिकीर्षन्तं तं मनुजं बोधयेत्। एवं ये ये उपयोगिनो भूम्यन्तर्गताः पदार्था यत्र यत्र वर्तेरन् ते ते पदार्थास्तत्तत्स्थानञ्चैतद्विद्याविद् जानाति ॥

आसां सकलप्रतिज्ञानां प्रमाणानि अस्मिन् संक्षिप्तग्रन्थे वक्तुं न शक्यन्ते। तथाप्यासां मण्डनं खण्डनं वा बुद्धिमद्भायोग्यं न स्यात् ॥

पृथिव्यां कतिपयेषु स्थानेषु यत्राधुना स्थलमस्ति तत्र पूर्वं समुद्र आसीत्। यत्रच समुद्रस्तत्र कदाचित् स्थलमासीत्। तदानीं ये प्राणिनो वृक्षाश्चात्र न्यवसन् तादृशा अधुना न दृश्यन्ते ॥

प्राचीनजन्तूनां विशेषा आश्चर्यकरा भवन्ति। ये

ज्ञानिनो यंकञ्चन प्राणिनं तदेकास्थिनिरीक्षणमात्रेण कदाचित् परिचिन्वन्ति किम्पुनस्ते प्राक्तनजन्तून् तदस्थिपञ्जरावलोकनेन जानन्तीति वाच्यम् । अथ पाषाणान्तर्गतप्राणिनां वर्णनमतिसंक्षेपतः क्रियते ॥

प्राचीनकालिको हस्ती हस्तषट्काधिकोच्छ्रायो हस्तैकादशकाधिकदैर्घ्यविशिष्टो रोमाक्रान्तशरीरश्चासीत् । तस्य दृढदन्तावतिकुटिलौ दैर्घ्ये करषट्कमितावास्ताम् ॥

प्राचीनकालिको महामकरो दैर्घ्ये चयस्त्रिंशत्कर आसीत् । तस्यास्थीनि इङ्गलण्डदेशे प्राप्नुवन्ति यच्चाधुना शीतवशान्न कञ्चन मकरः स्थातुं शक्नोति ॥

प्राक्तनी महागोधा सप्तचत्वारिंशद्धस्तदैर्घ्या ऽभवत् ॥

अथ मत्स्यमकरश्चरणाभावेन पक्षाभ्याञ्च मत्स्यसदृशो विंशतिकरदैर्घ्यश्चाभवत् । नरशिरःपरिमिते तस्याक्षिणी आस्ताम् ॥

अथ मकरकल्पसंज्ञको मत्स्यमकरेण किंचित् सट्ट-
ग्रस्तस्य शिरो ऽत्यन्तमल्पं ग्रीवाच सर्पवद्दीर्घा ऽभवत् ॥

उड्डीयमानमकरस्य मुखं मकरमुखवत् पक्षद्वयं वा-
तुलिपक्षवदभवत् ॥

एतावता पृथिवीस्थपदार्थानां या व्यवस्था दर्शिता
तस्याः कारणानि निरूपयितुं पार्थिवांशव्यवस्याहेतु-
विचाराख्यं प्रकरणमारभ्यते ॥

भूगोलमध्यभागो ऽग्निना द्रवीकृ-
तोऽस्तीति सम्भाव्यते ॥ ३२ ॥

दृदञ्च वक्ष्यमाणानुमानेन कल्प्यते । यदि भूम्यु-
ष्णता सूर्यसम्बन्धादेव भवेत्तर्हि भूपृष्ठे तदाधिक्येन
भवितव्यं गम्भीरखन्यादौ तच्यूनताच स्यात् । परन्तु
वस्तुत दृदं वैपरीत्येनानुभूयते गाम्भीर्याधिक्यानुसा-
रेण खन्यादरुष्णताधिक्यदर्शनादिति ॥

बहुषु स्थानेष्वाग्नेयाः पर्व्वता वर्त्तन्ते । तेषामुत्पत्तिरेवम्भवति पृथिवीमध्यादागतो द्रवीभूतः पार्थिवांशोऽत्यन्तवेगेन पूर्वस्थितम्पार्थिवांशपुटं स्फाटयति तिर्यक्करोतिच । ततस्तच्छेदाद्वह्निर्निर्गत्य पर्वतो भवति ॥

तत्पर्वतशिखरे मेघाः समागच्छन्ति ततश्च सरित उत्पद्यन्ते ॥

सरितः प्रवाहाघातैस्तत्पर्वतस्यावयवाश्चूर्णीभूय जलमिश्रिताः समुद्रङ्गच्छन्ति । तच समुद्रे सरितो जलं स्थिरम्भवति तेन तन्मिश्राश्चूर्णीभूतपर्वतावयवा अधः सञ्चीयन्ते ततस्तचैकमल्पद्वीपमुत्पद्यते नद्याश्च मुखद्वयं जायते ॥

पुनः प्रतिमखमेवमेकैकमल्पद्वीपमुत्पद्यते एवमनेकानि सरिन्मुखानि जायन्ते ॥

अनयैव युक्त्या गङ्गायाः शतमुखान्युत्पन्नानि । तन्मुखश्यामस्थानं सुन्दरवनाख्यम् ॥

तत्र जाते एकैकाल्पद्वीपे बहवो वृक्षा जन्त्वस्थीनिच समायान्ति प्रतिद्वीपतटं शङ्खविशेषाश्चायान्ति ॥

पुनर्यदि तत्र ज्वलनपर्वत उत्पद्यते तर्हि तत्र स देश उच्छ्रितो भवेत् शङ्खादीनि सामुद्रवस्तूनिच तत्र लभ्यानि भवेयुर्यथा बहुषु पर्वतशिखरेषु लभ्यन्ते ॥

नैतत्सर्वमल्पकालेन सम्पद्यते अतो ऽल्पायुषा मनुजेन नेदन्तदारभ्यकालादद्यावधि अवलोकयितुं शक्यते किन्तु यथा विचित्रपरिमाणान् वनवृक्षानवलोक्य ये महान्तो वृक्षास्ते पूर्वमल्पा आसन् येचाल्पास्ते महान्तो भविष्यन्तीत्यनुमीयते तद्वदल्पसरित्सङ्गमे समुत्पन्नस्याल्पद्वीपस्यानुदिनं विकारं तत्रत्यविचित्रपदार्थांश्च दृष्ट्वा ऽन्यत्र वर्तमानस्यैतादृक्भूप्रदेशस्योत्पत्तेः प्रोक्तिकारणमन्तरेणान्यत्कारणं न स्यादित्यनुमीयते ॥

सुन्दरवनभूमिर्यदि भूम्यन्तर्गतवह्निनोच्छ्रिता भवेत् तदा तद्देशपूर्ववर्तिनां व्याघ्रभृगमकरादीनामस्थीनि पृथक् संयुक्तानिच तन्मृदि मग्नानि प्राप्नुयुः । तथा

प्राचीनकाले ये देशा एवमुत्पन्नास्तेष्वपि तत्प्राचीनव
लिकानां जन्तूनामस्थ्यादीनि लभेरन् । वस्तुत र
लभन्ते यथा पूर्वप्रकरणे उक्तम् । अथैतावता अस्
द्विचारविषयाणामेतेषां प्रस्तुतपदार्थानां तत्त्वनिर्ण
यस्य प्रत्यक्षमात्रेणासम्भवादिदानीमनुमानाख्यप्रमाणा
न्तरमभिधातुमुपक्रमते ॥

❋ ॥ इति चतुर्थोध्यायः समाप्तः ॥ ❋

CORRIGENDA.

—o-o-o—

At Page	1	line	4	*For* "First Book" *read* Second Book.
„ „	8	„	30	Subjoin the words—"Leibnitz, who made the discovery at the same time, is called the Differential and Integral Calculus."
„ „	9	„	9	*For* "comparative" *read* respective.
„ „	10	„	10	*For* "line" *read* time.
„ „	23	„	15	*For* "simple" *read* simple multiple.
„ „	37	„	21	*For* "and ascertain Nitrogen, and Carbon; that it consists of Oxygen, Hydrogen," *read* and ascertain that it consists of Oxygen, Hydrogen, Carbon, and Nitrogen.
„ „	५६	„	८	*For* "अङ्गारिकायितन" *read* अङ्गारायितम्,—and so elsewhere, wherever the इक of the name of the Acid has been inadvertently retained in the name of the Salt.
„ „	८२	„	७	*For* "चतुर्थाध्यायः" *read* द्वतीयाध्यायः ।

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